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SN7402N	14	.25
SN7403N	14	.25
SN7404N	14	.25
SN7405N	14	.25
SN7406N	14	.45
SN7407N	14	.29
SN7408N	14	.25
SN7409N	14	.25
SN7410N	14	.25
SN7411N	14	.25
SN7412N	14	.49
SN7413N	14	.39
SN7414N	14	.49
SN7416N	14	.25
SN7417N	14	.25
SN7420N	14	.19
SN7421N	14	.49
SN7422N	14	.49
SN7423N	16	.59
SN7425N	14	.29
SN7426N	14	.29
SN7427N	14	.25
SN7428N	14	.59
SN7430N	14	.25
SN7432N	14	.29
SN7437N	14	.25
SN7438N	14	.29
SN7439N	14	.59
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	1.25
SN7444N	16	1.25
SN7445N	16	.69
SN7446N	16	.69
SN7447N	16	.69
SN7448N	16	.69
SN7450N	14	.19
SN7451N	14	.19
SN7453N	14	.19
SN7454N	14	.19
SN7459N	14	.25
SN7460N	14	.39
SN7470N	14	.29
SN7472N	14	.29
SN7473N	14	.35
SN7474N	14	.35
SN7475N	16	.45
SN7476N	16	.35
SN7479N	14	4.95
SN7480N	14	.89
SN7482N	14	1.49
SN7483N	16	.59
SN7485N	16	.59
SN7486N	14	.35
SN7489N	16	2.25
SN7490N	14	.39
SN7491N	14	.79
SN7492N	14	.39
SN7493N	14	.39
SN7494N	14	.89
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	3.25
SN74100N	24	1.95
SN74104N	14	1.19
SN74105N	14	1.19
SN74107N	14	.29
SN74109N	16	.39
SN74116N	24	1.49
SN74121N	14	.39
SN74122N	14	.69
SN74123N	16	.49
SN74125N	14	.45
SN74126N	14	.49
SN74132N	14	.49
SN74136N	14	.69
SN74141N	16	.89
SN74142N	16	3.95
SN74143N	24	3.95
SN74144N	24	3.95
SN74145N	16	.59
SN74147N	16	1.49
SN74148N	16	1.19
SN74150N	24	1.19
SN74151N	16	.59
SN74152N	14	.59
SN74153N	16	.59
SN74154N	24	1.25
SN74155N	16	.59
SN74156N	16	.59
SN74157N	16	.59
SN74160N	16	.69
SN74161N	16	.69
SN74162N	16	.69
SN74163N	16	.69
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.89
SN74167N	16	2.95
SN74170N	16	1.29
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SN74174N	16	.69
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SN74179N	16	1.49
SN74180N	14	.69
SN74181N	24	1.95
SN74182N	16	.69
SN74184N	16	2.49
SN74185N	16	2.49
SN74190N	16	.69
SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.69
SN74196N	14	.69
SN74197N	14	.69
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74276N	20	2.49
SN74279N	16	.79
SN74283N	16	1.49
SN74284N	16	2.95
SN74285N	16	2.95
SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

74LS

Part No.	**Pins	Price
74LS00	14	.25
74LS01	14	.25
74LS02	14	.29
74LS03	14	.25
74LS04	14	.35
74LS05	14	.29
74LS08	14	.29
74LS09	14	.29
74LS10	14	.29
74LS11	14	.35
74LS12	14	.35
74LS13	14	.39
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.29
74LS22	14	.29
74LS26	14	.29
74LS27	14	.29
74LS28	14	.35
74LS30	14	.29
74LS32	14	.39
74LS33	14	.55
74LS37	14	.35
74LS38	14	.35
74LS40	14	.29
74LS42	16	.55
74LS47	16	.75
74LS48	16	.75
74LS49	16	.75
74LS51	14	.25
74LS54	14	.29
74LS55	14	.29
74LS73	14	.39
74LS74	14	.49
74LS75	16	.39
74LS76	16	.39
74LS78	14	.39
74LS83	16	.65
74LS85	16	.89
74LS86	14	.39
74LS90	14	.55
74LS92	14	.55
74LS93	14	.55
74LS95	14	.79
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.39
74LS113	14	.39
74LS114	14	.39
74LS122	14	.49
74LS123	16	.89
74LS125	14	.49
74LS126	14	.49
74LS132	14	.59
74LS133	16	.59
74LS136	14	.39
74LS138	16	.89
74LS139	16	.79
74LS151	16	.59
74LS153	16	.59
74LS154	24	1.29
74LS155	16	.69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	1.19
74LS168	16	1.19
74LS169	16	1.19
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.69
74LS175	16	.69
74LS181	24	2.95
74LS190	16	.89
74LS191	16	.89
74LS192	16	.79
74LS193	16	.79
74LS194	16	.69
74LS195	16	.69
74LS197	14	.79
74LS221	16	.89
74LS240	20	1.09
74LS241	20	1.09
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.49
74LS245	20	1.49
74LS247	16	.89
74LS248	16	1.09
74LS249	16	1.09
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.69
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.79
74LS298	16	.89
74LS352	16	1.29
74LS353	16	1.29
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.49
74LS374	20	1.49
74LS375	16	.69
74LS386	14	.45
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
81LS95	20	1.49
81LS97	20	1.49

74S/PROMS*

Part No.	**Pins	Price
74S00	14	.35
74S02	14	.35
74S03	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.39
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
74S40	14	.39
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S85	16	2.49
74S86	14	.55
74S112	16	.55
74S113	14	.55
74S114	14	.55
74S133	16	.45
74S134	16	.50
74S135	16	.69
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.55
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.49
74S174	16	1.19
74S175	16	1.19
74S188*	16	1.49
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	2.25
74S241	20	2.25
74S242	14	2.49
74S243	14	2.49
74S244	20	2.49
74S251	16	1.19
74S253	16	1.19
74S257	16	1.19
74S258	16	1.19
74S260	14	1.19
74S280	14	1.95
74S287*	16	1.95
74S288*	16	1.95
74S373	20	2.49
74S374	20	2.49
74S387*	16	1.95
74S471*	20	5.95
74S472*	20	4.95
74S473*	20	4.95
74S474*	24	4.95
74S475*	24	4.95
74S570*	16	2.95
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74S572*	18	4.95
74S573*	18	4.95
74S940	20	2.49
74S941	20	2.49

CA—LINEAR

Part No.	**Pins	Price
CA3010H		1.35
CA3039H		1.35
CA3046N	14	1.35
CA3059N	14	2.95
CA3060N	16	2.95
CA3065E	14	1.49
CA3080E	8	.89
CA3081N	16	.99
CA3082N	16	1.19
CA3083N	16	1.49
CA3086N	14	.69
CA3089N	16	1.69
CA3096N	16	1.49
CA3130E	8	.89
CA3140E	8	.79
CA3160H		1.95
CA3161E	16	2.95
CA3162E	16	6.95
CA3189E	16	1.59
CA3401N	14	.59

CD—CMOS

Part No.	**Pins	Price
CD4000	14	.29
CD4001	14	.29
CD4002	14	.29
CD4006	14	1.19
CD4007	14	.29
CD4009	16	.59
CD4010	16	.59
CD4011	14	.29
CD4012	14	.29
CD4013	14	.39
CD4014	16	1.19
CD4015	16	.39
CD4016	14	.49
CD4017	16	1.19
CD4018	16	.99
CD4019	16	.59
CD4020	16	1.19
CD4021	16	1.19
CD4022	16	1.19
CD4023	14	.29
CD4024	14	.69
CD4025	14	.23
CD4026	16	2.49
CD4027	16	.45
CD4028	16	.69
CD4029	16	1.29
CD4030	14	.39
CD4034	24	2.49
CD4035	16	1.49
CD4040	16	1.19
CD4041	14	1.19
CD4042	16	.89
CD4043	16	.79
CD4044	16	.79
CD4046	16	1.19
CD4047	14	1.29
CD4048	16	.59
CD4049	16	.39
CD4050	16	.39
CD4051	16	.99
CD4052	16	.99
CD4053	16	.99
CD4056	16	2.95
CD4059	24	7.95
CD4060	16	1.49
CD4066	14	.59
CD4068	14	.39
CD4069	14	.29
CD4070	14	.39
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	1.19
CD4078	14	.49
CD4081	14	.29
CD4082	14	.29
CD4093	14	.49
CD4098	16	1.95
CD4506	16	1.19
CD4507	14	1.19
CD4508	24	3.95
CD4510	16	1.29
CD4511	16	1.19
CD4512	16	1.19
CD4514	24	2.49
CD4515	24	2.49
CD4516	16	1.19
CD4518	16	1.19
CD4519	16	.59
CD4520	16	1.19
CD4526	16	1.49
CD4528	16	1.49
CD4529	16	1.69
CD4543	16	1.95
CD4562	14	6.95
CD4566	16	1.39
CD4583	16	2.49
CD4584	14	.69
CD4723	16	1.19
CD4724	16	1.19
MC14409	16	13.95
MC14410	16	13.95
MC14411	24	11.95
MC14412	16	13.95
MC14419	16	7.95
MC14433	24	13.95
MC14538	16	1.19
MC14541	14	1.19

(More in Catalog)

MICROPROCESSOR CHIPS

Part No.	**Pins	Function	Price
CDP1802	40	CPU	$2.95
2650	40	MPU (2MHz)	9.95
MCS6502	40	MPU w/Clock	5.95
MCS6502B	40	MPU w/Clock at 3MHz	9.95
6800	40	CPU—8-bit (Internal Clock) 1MHz	14.95
6809E	40	CPU—8-bit (External Clock) 1MHz	14.95
INS8035N-6	40	MPU—8-bit (6MHz)	5.95
INS8039N	40	CPU-Sgl. chip 8-bit (128 bits Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	9.95
INS8070N	40	CPU (64 bytes RAM)	29.95
INS8073N	40	CPU w/Basic Micro Interpreter	29.95
P8085A	40	CPU	4.95
8086	40	CPU 16-bit 5MHz	24.95
8088	40	CPU 8/16-bit	29.95
8155	40	HMOS RAM I/O Port Timer	6.95
8748	40	HMOS EPROM MPU	24.95

Z80, Z80A, Z80B, Z8000 SERIES

Part No.	**Pins	Function	Price
Z80	40	CPU (MK3880N)(780C) 2MHz	$3.95
Z80-CTC	28	Counter Timer Circuit	3.95
Z80-DART	40	Dual Asynchronous Rec./Trans.	10.95
Z80-DMA	40	Direct Memory Access Circuit	9.95
Z80-PIO	40	Parallel I/O Interface Controller	3.95
Z80-SIO/0	40	Serial I/O (TxCB and RxCB Bonded)	12.95
Z80-SIO/1	40	Serial I/O (Lacks DTRB)	12.95
Z80-SIO/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80-SIO/9	40	Serial I/O	12.95
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	4.49
Z80A-CTC	28	Counter Timer Circuit	4.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-PIO	40	Parallel I/O Interface Controller	3.95
Z80A-SIO/0	40	Serial I/O (TxCB and RxCB bonded)	12.95
Z80A-SIO/1	40	Serial I/O (Lacks DTRB)	12.95
Z80A-SIO/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80A-SIO/9	40	Serial I/O	12.95
Z80B	40	CPU (MK3880N-6) 6MHz	9.95
Z80B-CTC	28	Counter Timer Circuit	12.95
Z80B-DART	40	Dual Asynch. Receiver/Transmitter	19.95
Z80B-PIO	40	Parallel I/O Interface Controller	12.95
Z8001	48	CPU Segmented	44.95
Z8002	40	CPU Non-Segmented	34.95
Z8030	40	Serial Comm. Controller	44.95
Z8036	40	Counter/Timer & Parallel I/O Unit	29.95

6500/6800/68000 SERIES

Part No.	**Pins	Function	Price
MC6502A	40	MPU with clock and RAM (2MHz)	6.95
MC6520	40	Peripheral Inter. Adapter	4.95
MC6800	40	MPU	2.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6809E	40	CPU (1MHz) External (Locking)	14.95
MC6821	40	Peripheral Inter. Adapt (MC6820)	2.95
MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	9.95
MC6850	24	Asynchronous Comm. Adapter	3.95
MC6852	24	Synchronous Serial Data Adapter	5.75
MC6860	24	0-600bps Digital MODEM	7.95
MC68000L8	64	MPU 16-Bit (8MHz)	49.95
MC68488P	40	General Purpose Int. Adapter	9.95
MC68652P2	40	Multi-Protocol Comm. Controller	24.95
MC68661PB	28	Enhanced Prog. Comm. Int.	9.95
MCM68764	24	64K EPROM (450ns)	24.95
SY6522	40	Peripheral Inter. Adapter	7.95

8080A SERIES

Part No.	**Pins	Function	Price
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
INS8080A	40	CPU	2.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
8156	40	RAM with I/O Port and Timer	6.95
INS82C06	20	Octal D Flip Flop Tri-State (74C374)	2.49
DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	2.95
DP8216	16	Bi-Directional Bus Driver	1.95
DP8224	16	Clock Generator/Driver	2.25
DP8226	16	Bus Driver	2.25
DP8228	28	System Cont./Bus Driver (74S428)	3.49
DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	3.95
INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
INS8246	20	20-Key Keyboard Encoder (74C923)	4.95
INS8247	28	Display Controller (74C911)	8.95
INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	6.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	5.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	8.95
DP8303	20	8-Bit Tri-State Bi-Directional Trans.	3.95
DP8304	20	8-bit Bi-Directional Receiver	2.95
DP8307	20	8-bit Bi-Directional Receiver	2.95
DP8308	20	8-bit Bi-Directional Receiver	2.95
DP8310	20	Octal Latched Peripheral Driver	4.95
8741	40	8-bit Univ. Peripheral Interface	29.95
8755	40	16K EPROM with I/O	24.95

DISK CONTROLLERS

Part No.	**Pins	Function	Price
INS1771-1	40	Single Density	16.95
FD1791	40	Single/Dual Density (Inv.)	29.95
FD1793	40	Single/Double Density (True)	29.95
FD1795	40	Dual Density/Side Select (Inv.)	29.95
FD1797	40	Dual Density/Side Select True	29.95

SPECIAL FUNCTION

Part No.	**Pins	Function	Price
DS0025CN	8	Dual MOS Clock Driver (5MZ)	2.49
DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS2651	28	Communication Chip	8.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	7.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.95
COP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss Int.	5.95
COP470N	20	32-seg VAC Fluor. Drvr. (20-pin pkg.)	3.25
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

DYNAMIC RAMS

Part No.	**Pins	Function	Price
1103	18	1024x1 (300ns)	.99
4027	16	4096x1 (250ns)	2.49
4116N-2	16	16,384x1 (150ns)	1.89 - 8/14.95
4116N-3	16	16,384x1 (200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1 (250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1 (150ns)	6.95 - 8/49.95
4164N-200	16	65,536x1 (200ns)	5.95 - 8/44.95
MM5261	18	1024x1 (300ns)	.49 - 8/1.95
MM5262	22	2048x1 (365ns)	.10
MM5270	18	4096x1 (250ns) MK4096	4.95
MM5280	22	4096x1 (200ns) 2107	3.95
MM5290-2	16	16,384x1 (150ns)	1.89 - 8/14.95
MM5290-3	16	16,384x1 (200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1 (250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1 (200ns)	1.69

STATIC RAMS

Part No.	**Pins	Function	Price
1101	16	256x1 (650ns)	1.49
2101	22	256x4 (450ns) 8101	2.49
2102	16	1024x1 (350ns)	.89
21L02	16	1024x1 (450ns) L.P.	1.49
2111	18	256x4 (450ns) 8111	2.95
2112	16	256x4 (450ns) MOS	1.95
2114	18	1024x4 (450ns)	1.49 - 8/9.95
2114L	18	1024x4 (450ns) L.P.	1.95 - 8/13.95
2114-2	18	1024x4 (200ns)	1.75 - 8/11.95
2114L-2	18	1024x4 (200ns) L.P.	2.25 - 8/14.95
2147	18	4096x1 (70ns)	4.95
2148	18	1024x4 (70ns)	4.95
TMS4045	18	1024x4 (450ns)	3.95
TMS40L47-45	20	1024x4 (450ns)	2.95
5101	22	256x4 (450ns) CMOS	2.95
MM5257	18	4096x1 (450ns) 4044	4.95
HM6116P-3	24	2048x8 (150ns) CMOS	5.95
HM6116P-4	24	2048x8 (200ns) CMOS	4.95
HM6116LP-4	24	2048x8 (200ns) L.P. CMOS	5.49
HM6264P-15	28	8192x8 (150ns) CMOS	39.95
27LS00	16	256x1 (80ns) L.P.	9.95
7489	16	16x4 (50ns) 3101	2.25
74C920	22	256x4 (250ns)	3.95
74C921	18	256x4 (250ns) CMOS	3.95
74C929	16	1024x1 (250ns) CMOS (6501)	3.95
74C930	18	1024x1 (250ns) CMOS (6518)	3.95
74S189	16	16x4 (35ns) 93405	1.95
74S200	16	256x1 (80ns) 93410	3.95
74S206	16	256x1 (60ns) 93411	3.95
74S289	16	16x4 (35ns) 3101	2.25
82S10	16	1024x1 (50ns) O.C. (93415)	3.95
82S25	16	16x4 (50ns) O.C. (74S289)	2.25

PROMS / EPROMS

Part No.	**Pins	Function	Price
1702A	24	256x8 (1us)	4.95
2708	24	1024x8 (450ns)	3.95
2708-5	24	1024x8 (550ns) SM00246	2.95
TMS2516	24	2048x8 (450ns) 2716	5.95
TMS2532	24	4096x8 (450ns) NMC2532	6.95
TMS2564	28	8192x8 (450ns)	14.95
TMS2716	24	2048x8 (450ns) 3 voltage	9.95
2716	24	2048x8 (450ns)	4.95
2716-1	24	2048x8 (350ns)	5.95
27160-5	24	2048x8 (550ns)	4.49
2732	24	4096x8 (450ns)	6.95
2732A-3	24	4096x8 (300ns)	7.95
2732A-4	24	4096x8 (450ns) 21V	6.95
27320-4	24	4096x8 (550ns)	5.95
27580-A	24	1024x8 (450ns)	2.95
2764-4	28	8192x8 (450ns)	9.95
2764-3	28	8192x8 (300ns)	14.95
MM52040	24	512x8 (1us)	4.95
MCM68764	24	8192x8 (450ns)	24.95
27128	28	16,384x8 (450ns) 128K EPROM	59.95
74S188	16	32x8 PROM O.C. (6330-1)	1.49
74S287	16	256x4 PROM T.S. (6301-1)	1.95
74S288	16	32x8 PROM T.S. (6331-1)	1.95
74S387	16	256x4 PROM O.C. (6300-1)	1.95
74S471	20	256x8 PROM T.S. (6309-1)	5.95
74S472	20	512x8 PROM T.S. (6349-1)	4.95
74S473	20	512x8 PROM O.C. (6348)	4.95
74S474	24	512x8 PROM T.S. (DM87S296N)	4.95
74S475	24	512x8 PROM O.C. (6340)	4.95
74S476	18	1024x4 PROM T.S.	6.95
74S478	24	1024x8 PROM T.S.	8.95
74S570	16	512x4 PROM O.C. (6305)	2.95
74S571	16	512x4 PROM T.S. (6306)	2.95
74S572	18	1024x4 PROM O.C. (6352)	4.95
74S573	18	1024x4 PROM T.S. (82S137)	4.95
82S23	16	32x8 PROM O.C. (27S18)	2.95
82S115	24	512x8 PROM T.S. (27S15)	9.95
82S123	16	32x8 PROM T.S. (27S19)	2.95
82S126	16	256x4 PROM O.C. (27S20)	2.95
82S129	16	256x4 PROM T.S. (27S21)	2.95
82S130	16	512x4 PROM O.C. (27S12)	3.95
82S185	18	2048x4 PROM T.S. (TBP24S81)	9.95
82S190	24	2048x8 (80ns)	14.95
82S191	24	2048x8 (80ns)	14.95
DM87S180N	24	1024x8 PROM O.C. (82S180)	9.95
DM87S181N	24	1024x8 PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4 PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4 PROM T.S. (82S185)	9.95
DM87S190N	24	2048x4 PROM O.C. (82S190)	14.95
DM87S191N	24	2048x8 PROM T.S. (82S191)	14.95

DATA ACQUISITION

Part No.	**Pins	Function	Price
DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	1.49
MC1408L8	16	8-bit D/A Converter (DAC0808LCN)	2.25
ADC0803LCN	20	8-bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-bit A/D Converter (1LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
ADC0817	40	8-bit A/D Converter (16-Ch. Multi.)	9.95
DAC1000	24	10-bit D/A Conv. Micro. Comp. (0.05%)	7.95
DAC1008	20	10-bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1020	16	10-bit D/A Conv. (0.05% Lin.)	7.95
DAC1022	16	10-bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-bit D/A Conv. (0.20% Lin.)	6.95
LM334Z		Constant Current Source	1.19
LM335Z		Temperature Transducer	1.40
LM399H		Temp. Comp. Prec. Ref. (.5ppm/C°)	5.00
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	1-9	10-99	100-up
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14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.45	.42	.39
40 pin LP	.49	.46	.43

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14 pin SG	.43	.39	.37
16 pin SG	.47	.43	.41
18 pin SG	.53	.49	.47
24 pin SG	.69	.65	.61
28 pin SG	.81	.76	.72
36 pin SG	1.09	1.03	.97
40 pin SG	1.21	1.14	1.08

LP — SG — ST — WW

SOLDERTAIL STANDARD (TIN)

	1-9	10-99	100-up
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16 pin ST	.34	.32	.30
18 pin ST	.38	.36	.34
20 pin ST	.45	.43	.41
24 pin ST	.49	.46	.43
28 pin ST	.69	.67	.63
40 pin ST	.99	.95	.89

WIRE WRAP SOCKETS (GOLD) LEVEL #3

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10 pin WW	.65	.62	.59
14 pin WW	.65	.62	.59
16 pin WW	.69	.65	.61
18 pin WW	.89	.85	.79
20 pin WW	1.09	1.05	.99
22 pin WW	1.25	1.19	1.15
24 pin WW	1.29	1.23	1.18
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36 pin WW	1.85	1.75	1.69
40 pin WW	1.99	1.89	1.79

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INTERSIL

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Part No.	**Pins	Function	Price
7045IPI	28	CMOS Precision Timer	11.95
7045EV/Kit*	28	Stopwatch Chip, XTL	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	9.95
FE0203D		3½ Digit LCD Display for 7106 & 7116	19.95
7106EV/Kit*	40	IC, Circuit Board, Display	34.95
7107CPL	40	3½ Digit A/D (LED Drive)	11.95
7107EV/Kit*	40	IC, Circuit Board, Display	29.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD.	15.95
7201IUS		Low Battery Volt Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	24	Stopwatch Chip, XTL	14.95
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7206CEV/Kit*	16	Tone Generator Chip, XTL	7.95
7207AIPD	14	Oscillator Controller	5.95
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7215IPG	24	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	24	4 Func. Stopwatch Chip, XTL	14.95
7216AIJI	28	8 Digit Univ. Counter C.A.	29.95
7216CIJI	28	8 Digit Freq. Counter C.A.	24.95
7216DIPI	28	8 Digit Freq. Counter C.C.	19.95
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
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Part No.	**Pins	Price
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74HC03	14	.75
74HC04	14	.59
74HCU04	14	.65
74HC08	14	.59
74HC10	14	.59
74HC11	14	.59
74HC14	14	.85
74HC20	14	.59
74HC27	14	.59
74HC32	14	.75
74HC42	16	.99
74HC51	14	.75
74HC58	14	.75
74HC73	14	.79
74HC74	14	.79
74HC75	16	.89
74HC76	16	.79
74HC85	16	1.59
74HC86	14	.69
74HC107	14	.79
74HC109	16	.79
74HC112	16	.79
74HC113	14	.79
74HC132	14	.99
74HC133	16	1.95
74HC138	16	1.09
74HC139	16	.99
74HC147	16	1.19
74HC151	16	.89
74HC153	16	.99
74HC154	24	2.49
74HC157	16	.89
74HC158	16	.89
74HC160	16	1.29
74HC161	16	1.29
74HC162	16	1.29
74HC163	16	1.29
74HC164	14	1.29
74HC165	16	2.79
74HC173	16	1.69
74HC174	16	.99
74HC175	16	.99
74HC192	16	1.39
74HC193	16	1.39
74HC194	16	1.09
74HC195	16	1.09
74HC237	16	2.95
74HC240	20	1.95
74HC241	20	1.95
74HC242	14	1.95
74HC243	14	1.95
74HC244	20	1.95
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74HC259	16	1.49
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74HC373	20	2.39
74HC374	20	2.39
74HC390	16	1.49
74HC393	14	1.49
74HC533	20	2.39
74HC534	20	2.39
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74HC4017	16	2.19
74HC4020	16	1.39
74HC4024	14	1.59
74HC4040	16	1.39
74HC4060	16	1.39
74HC4075	14	.59
74HC4078	14	.69
74HC4511	16	2.69
74HC4514	24	3.79
74HC4538	16	2.39
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74HCU04 is unbuffered. All others are buffered.

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PAL14H4	20	Quad 14-Input AND-OR Gate Array (High Output)	3.95
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PAL12L6	20	Hex 12-Input AND-OR-Invert Gate Array (Low Output)	3.95
PAL14L4	20	Quad 14-Input AND-OR-Invert Gate Array (Low Output)	3.95
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74C—C/MOS

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74C02	14	.35
74C04	14	.29
74C08	14	.35
74C10	14	.35
74C14	14	.69
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.39
74C48	16	1.95
74C73	14	.79
74C74	14	.69
74C85	16	1.95
74C86	14	.39
74C89	16	5.95
74C90	14	1.19
74C93	14	1.19
74C95	14	1.39
74C107	14	.89
74C151	16	2.49
74C154	24	3.49
74C157	16	2.25
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.49
74C173	16	1.19
74C174	16	1.19
74C175	16	1.19
74C192	16	1.49
74C193	16	1.69
74C195	16	1.39
74C221	16	1.95
74C240	20	1.95
74C244	20	1.95
74C373	20	2.49
74C374	20	2.49
74C901	14	.59
74C903	14	.59
74C906	14	.59
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.69
80C97	16	.69

LINEAR

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TL072CP	8	1.39
TL074CN	14	1.95
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TL082CP	8	1.19
TL084CN	14	1.95
LM301CN	8	.35
LM302H		1.95
LM304H		1.95
LM305H		.99
LM307CN	8	.45
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.75
LM311CN	8	.69
LM312H		2.49
LM317T		1.19
LM317K		3.95
LM318CN	8	1.95
LM319N	14	1.95
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320T-5		.89
LM320T-12		.89
LM320T-15		.89
LM323K		5.95
LM324N	14	.59
LM337T		1.95
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340T-5		.79
LM340T-12		.79
LM340T-15		.79
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LM348N	14	.99
LM350K		4.95
LF355N	8	1.10
LF356N	8	1.10
LM370N	14	4.49
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LM377N	14	1.95
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LM382N	14	1.39
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TL494CN	16	3.95
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NE550A	14	1.95
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LM556N	14	.69
NE564N	16	2.95
LM565N	14	1.19
LM566CN	8	1.49
LM567V	8	.99
NE570N	16	3.95
LM703CN	8	1.19
LM709N	14	.49
LM710N	14	.69
LM711N	14	.79
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LM733N	14	1.00
LM739N	14	1.95
LM741CN	8	.35
LM747N	14	.69
LM748N	8	.59
LM1310N	14	1.49
LM1458CN	8	.59
LM1488N	14	.89
LM1489N	14	.89
LM1496N	14	1.95
LM1800N	16	2.49
LM1871N	18	2.95
LM1872N	18	3.25
LM1877N-9	14	2.49
LM1889N	18	2.25
LM1896N	14	2.95
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LM3909N	8	.99
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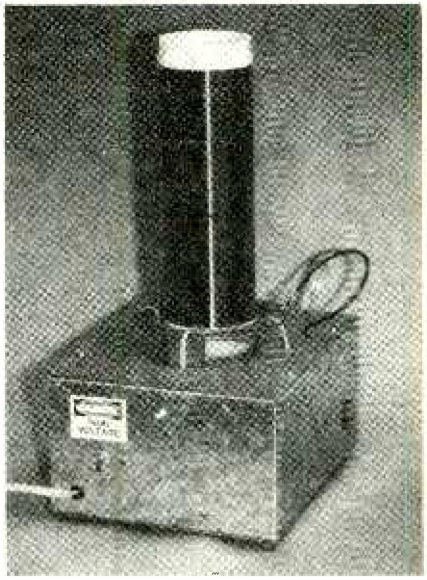
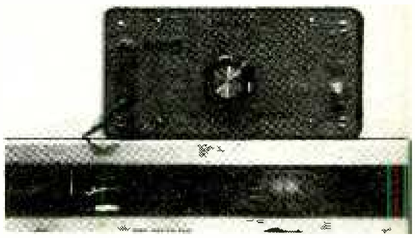


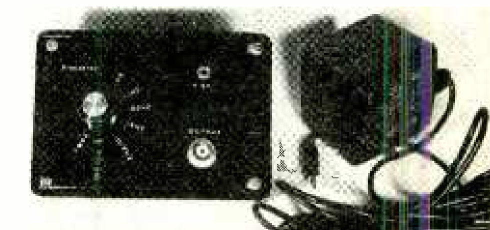
Tesla's Coil—page 19

FEATURES

DEPARTMENTS



Broadcast Booster—page 62



Crystal-Controlled Pulse Generator—page 78

Special Projects®
The magazine for people who build electronic projects

#10
SPRING 1984

Tesla is back!

Several years ago I received a letter from a reader stating that isn't it about time we forget about publishing Tesla-coil projects? The letter was in response to a mini-project that produced a two-inch spark under favorable conditions. That was one letter. I received over 200 letters from happy readers who built the project and enjoyed playing with it. One reader reported that it was more fun than rubbing cat fur on a glass rod to get a spark, especially since his cat didn't like the idea! Well, we did it again—in this issue of **Special Projects** you will find the biggest, grandest, most dramatic Tesla coil ever put on the pages of a magazine. To build a larger unit may require a public utility license!

How big is big? Take a look at the cover photo and notice that the incandescent bulb is glowing, due to the spark energy passing through it. That's right; the nitrogen gas inside a 100-watt bulb can be made to glow with this Tesla coil. But enough—build the project and send me letters about your results.

Another project that excited us was Caesar's Clock—a timepiece that reads out in Roman numerals. Not only is it accurate, it draws a crowd in my office during coffee breaks.

And we have a bunch more of terrific projects for the builder. Take a look at the 100-MHz Scope Probe—it's a winner! Also, our Broadcast Booster adds receiving punch for those readers who tune the AM broadcast band for distant reception. And, Ed Noll, one of our top writers, gives the details on erecting SWL antennas at ultra-low cost! All in all, I think that this issue is one of our best! Do you agree?

A bit of news—the next issue of **Special Projects** will have a new name. It will be **Hands-On Electronics**—a name that is more descriptive of what is between the covers. Also, you will note some slight changes in this issue that will be carried foreward. **Hands-On Electronics** will cover the various hobby groups associated with project builders. A change? Not really! Our basic theme will always be projects, projects, projects....

So, until next time, enjoy building your favorite projects and let us know what you would like to see in the following issues of **Hands-On Electronics**.

Julian S. Martin

Julian S. Martin, KA2GUN
Editor

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LETTERS

CAN'T FIND Q

My Dad gets many electronics magazines delivered to our home, and I read them all. No, I don't understand all of the articles in them, but, from time to time, I like to build some of the circuits that they provide. A major problem is that many of the transistors used are not listed in my dinky transistor-substitution guide. Do you have any suggestion other than telling me to buy some very expensive semiconductor substitution guide?

DAN P.
Grand Rapids, MI

Believe it or not, once upon a I time—recommended to my readers that they buy a very expensive, and comprehensive, semiconductor guide that we use at the office. Unfortunately, the substituted devices were as unattainable as the original part. So now I recommend substitution guides that are keyed to a ready supply of semiconductors that are found nationwide in many electronics and service parts stores. One such guide just crossed my desk, the ECG Semiconductor Master replacement Guide. *Published by Sylvania/Philips, the Guide gives replacement and substitution items that are available at local parts distributors, who sell them as well as the book itself. The Guide goes for $3.25. For the name and location of the distributor nearest you, just dial 1-800-225-8326 toll free. In Massachusetts; 1-617-890-6107.*

Other companies do the same bit, provide a replacement guide that is serviceable by their on-hand parts. RCA does a fine job, and so does Radio Shack. If you care to, purchase all three guides mentioned above and the odds are in your favor of not only finding a suitable replacement semiconductor, but being able to purchase it at a reasonable cost.

MINI-BUILDER

Lately, **Special Projects** has been presenting some interesting, and highly useful, pocket test projects. Your *Dot-Bar Generator* in the last issue was a winner. Got any more?

NAOMI Y.
Miami, FL

Nice to get a letter from a Naomi from Miami, especially when the snow outside is knee deep. Yes, Naomi, our Pocket Pulse Generator in this issue of **Special Projects** *is dedicated to you.* This editor has big fingers, so he likes to put projects in a box twice the size of boxes used by most experimenters. Should any of our readers have trouble

(Continued on next page)

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LETTERS

Continued from previous page

assembling many parts in a small boxes, they should resort to larger boxes. The size is not important so much as the unit's function. Of course, when the project involves radio frequencies, we have a new ball game.

TELL IT AS IT IS

I hear tell that the telephone was invented by a German, Philip Reis, just before the War Between The States. Why do we continue to give the credit to the man who copied his idea?
BUBA S.
Sunrise, FL

In a cow's bladder he did! Reis stretched a cow's bladder over the side hole of a barrel. Touching the membrane was a pair of insulated wires carrying an intermittent electric current. The ends of the wires were wrapped around a magnetized knitting needle, which was inserted into the body of a violin. Now, when you talked into the cow's bladder, the violin reproduced sounds. Twenty years later, when that device was brought into court during a patent fight, the only sound heard was from the moaning cow whose bladder was stretched over a barrel hole.

*This editor gives Bell the credit for his initial work in developing the telephone, working with other inventors to add their devices to the telephone system, so that the combined technology promoted by what was probably the first private utility in the world, provided man with a useful voice-communications system that spanned the city, state, country, and oceans. Bell's contribution to communications was more than a chance cry for help. There's more on this subject in the January, 1984 issue of **Radio-Electronics** magazine.*

DX REPORT

The editor of **Special Projects** can run for President, as far as I'm concerned, ever since he put Don Jensen's shortwave column in **Special Projects**. I've been a Dx'er for about five years, and it was Don's earlier magazine articles that got me started. Now, I'd like to see you increase the shortwave-construction coverage in the magazine.
ALAN C.
Bend, OR

*Yep, Don is back! His column's brief absence from the magazine world has come to an end—or is it a new beginning. And, Alan, you will find more SW and DX projects in **Special Projects**. In fact, in this issue you will find Ed Noll's super article,* PVC Piping Puts Up SWL Antennas. *Ed is quite clever as a gadgeteer, which is complemented by his ability to write exciting articles for communications and theory buffs. Look for it in the following pages.*

HIS CONFESSION

I don't build projects as a rule, especially if there is a product available that will do the job. Of course, the price has to be reasonable. Recently, I built an audible continuity tester probe that works fine. It was a variation of one of Herb Friedman's projects a few issues back. It is a bit klutzy! Do you know of a product that will do the job at a good price?
JEFF B.
Franklin Park, IL

Well, what's a good price? And, why just a continuity tester? Recently, I held a Beckman DM73 digital multimeter in my hand and used it to troubleshoot an old AM radio. Besides being an audible continuity-checking probe, it measures voltage—AC or DC—and resistance with built-in autoranging. It can't measure AC

(Continued on page 100)

NEW PRODUCTS

30-Channel Programmable Scanner

Regency Electronics new 30-channel programmable scanner can not only tune in the action on any of 15,760 utility and amateur radio frequencies (in six VHF and UHF bands), it can even tell the time and has an alarm. And, like other scanners from Regency (the only American-made scanner brand), it boasts a wealth of advanced features that help make scanning more convenient. The Regency Model Z30 Scanner is available for $269.95 at Regency Electronics dealers.

The Regency Z30 comes pre-programmed for 30 popular frequencies in its six bands: low VHF (30-50 MHz), VHF two-meter amateur (144-148 MHz), high VHF (148-174 MHz), UHF ¾-meter amateur (440-450 MHz), standard UHF (450-470 MHz) and extended UHF (470-512 MHz). Its telescoping antenna is electronically optimized for each band, and an antenna jack is provided for a connection to an optional external antenna.

Programming any selected frequency into any selected channel is as easy as pushing a few keys on its keypad—even easier with the Z30's search feature. It will automatically search through every frequency (stopping every 5 KHz on the VHF bands, every 12.5 KHz on UHF) until it finds one that's active; then it pauses for four seconds, time enough to either program that frequency into memory or jot it down for later reference. Searching is fast: the Z30 covers 400 VHF frequencies (2 MHz) in about 34 seconds, 400 UHF frequencies (5 MHz) in about 30 seconds.

Scanning its thirty programmed channels takes only two seconds. A channel lock-out feature can exclude any selected channel(s) from being scanned; that is a useful way to keep generally busy channels available while prohibiting them from "locking in" on each scan.

A selected priority channel is sampled every two seconds. If active, it automatically overrides any other signal.

A scan-delay feature holds the channel open for approximately two seconds at the end of a transmission to wait for any reply; if scan delay is not selected, scanning resumes in about six-tenths of a second.

Channel selections are maintained in memory while power is connected, even if the scanner is not turned on. If power fails, or the scanner is transported or stored, a special backup circuit saves those selections for up to a week; the backup circuit doesn't use a battery, and so avoids the problem of damage from neglected batteries. If power is not restored in a week, programming defaults to the 30 factory-preprogrammed frequencies.

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Programming the Regency Z30 is simplified by a series of plain-language messages that appear on its vacuum-fluorescent display, identifying the current status and prompting the appropriate action.

For more information on the Z30 and location of dealers, contact Regency Electronics, Inc., 7707 Records St., Indianapolis, IN 46226-9986.

Disc-Drive Head Cleaner

Discwasher's Clean Runner, an interactive disc-drive cleaner, has been designed to lead the computer user step-by-step through the cleaning process. Most computer owners don't realize that preventive-cleaning maintenance of a personal computer is just as important as learning to use programs. Nothing is more frustrating than discovering that, all of a sudden, you can't run a program because the read/write heads have been contaminated by dirt build-up. Discwasher recommends that regular use of the Clean Runner will reduce disk-drive down-time and maintenance cost. In addition, it will extend the life of disk-drive heads and discettes.

The Discwasher Clean Runner uses a

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SHOWCASE

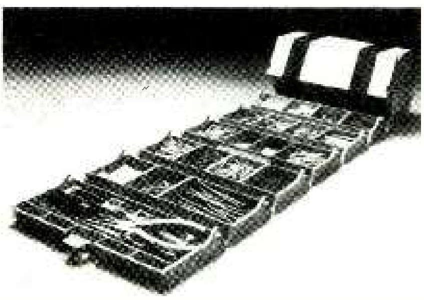
For more details use the free information card inside the back cover

lint-free cleaning surface bonded to a polyester discette. Its exclusive program directs the head(s) of a computer's drive to a different track for each cleaning, providing a contamination free cleaning surface. The Clean Runner is a dry system. It does not use chemicals, which may be harmful in themselves or may give off vapors harmful to the internal components of your disc drive and computer.

Each cleaning operation takes less than 30 seconds to complete, works on both single-sided or double-sided drives, and is programmed for 20 cleaning operations. For additional information, write to Discwasher, 1407 No. Providence Road, P.O. Box 6021, Columbia, MO 65205.

Portable Storage System

Rolykit, a unique patented rolling system, is able to hold dozens of different items in a small space without mixing them together. Rolykit consists of sturdy storage compartments that are "nested"



CIRCLE 743 ON FREE INFORMATION CARD

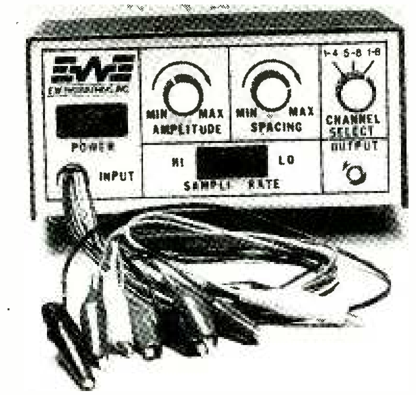
into a small portable unit that unrolls, exposing all of the storage bins ready for use.

It is great for holding hand tools, soldering aids, hobby items, electronicsparts, office supplies, etc. When not in use, Rolykit is an attractive compact case that takes up very little storage room. Each Rolykit comes with a set of dividers to subdivide trays to suit individual needs.

The two models available are: Model S-11 that rolls out to 3½ feet in length, is 10½ inches wide, and has 11 to 27 compartments, and retails for $22.95; Model S-14, rolls out to approximately 5 feet, 10½ inches wide, 14 to 38 compartments, and retails for $26.95. Rolykit is fully guaranteed and available from Triple-N-Enterprises, P.O. Box 2346, Spring, Texas 77379.

8-Trace Multiplexer

E. W. Engineering Model MPX 101 analog/digital, 8-trace oscilloscope, Multiplexer Module displays on single, or multiple, trace oscilloscopes up to 8 simultaneously occurring analog or digital (or both) signals in their real time and amplitude relationship.



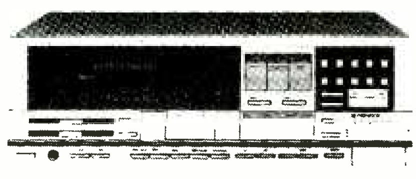
CIRCLE 744 ON FREE INFORMATION CARD

The MPX 101 was developed for designers, testers, hobbyists and repairmen who want to compare and analyze displayed signals in a timing-diagram format. The controls on the front panel of the metal case allow the operator to vary amplitude and pulse width of the displayed signals. The multiplexer is sold through traditional electronic instrument distribution channels. The suggested resale price is $99.00. For more information, write to E.W. Engineering, Inc., P.O. Box 624, Old Lyme, CT 06371.

Receiver with Audio-Video Control

A new home receiver, the SX-V90, by Pioneer has been engineered for today's sound with connections for tomorrow's technology. The SX-V90 captures the best of sight-and-sound with a combination that includes complete video compatibility and Pioneer's DDD (Digital Direct Decoder) FM circuit. Complete video capability means that the SX-V90 can handle up to two VCR units, a videodisc, a video monitor, television, and a computer game all at once with full switching capability, giving the SX-V90 the look and efficiency of a complete home-entertainment system. Also highlighting the SX-V90 are a number of vid-

(Continued on page 11)



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CIRCLE 713 ON FREE INFORMATION CARD

NEW PRODUCTS

(Continued from page 9)

eo functions which include dubbing between VCR 1 and VCR 2.

In addition, the simulated stereo feature lets you enjoy enhanced stereo from any mono program-source such as videotape, TV, FM, and AM, while DNR (Dynamic Noise Reduction) substantially reduces annoying noise and hiss. The SX-V90 offers quartz-PLL digital tuning for accuracy, and a total of 10 FM and 10 AM stations can be preset for instant touch recall.

The SX-V90's circuitry rejects interference from nearby FM stations, and eliminates the need for traditional noise filters. As a result, the SX-V90 features outstanding performance in critical areas such as adjacent channel interference, signal-to-noise ratio and channel separation.

The SX-V90 is also equipped with Pioneer's non-switching DC amplifier, a highly-efficient power source with low distortion characteristics. Continuous average power output totals 125 watts per channel minimum at 8 ohms, 20-20,000 Hz with no more than 0.005% total harmonic distortion.

Suggested retail price of the SX-V90 video-capable receiver is $799.95. Available at audio/video outlets throughout the US and Canada.

Digital LCD Thermometer

Obtain laboratory accuracy with Pacer's Model PT2000, pocket-size, digital thermometer. Low and high range settings indicate temperatures from −85 degrees to +2000° F with accuracy of 0.2% of reading. The unit features an LCD readout for long battery life and 2.5-second average response time. For $139.00, the PT 2000 comes complete

CIRCLE 746 ON FREE INFORMATION CARD

with battery. It is also available in a Celsius mode.

Different Type K thermoelement probes are available for checking surface, liquid, air, or material temperatures. Prices for probes vary accordingly. Pacer thermometers are also available in platinum resistance and semi-conductor type models. For further information contact: Customer Service, Pacer Industries, Inc., 1450 First Avenue, Chippewa Falls, WI 54729.

Spike Suppressors

SGL Waber's LineGard Spike Suppressors protect TV's, video games/recorders, and small computers from voltage spikes that occur in any electrical power system. Those spikes can destroy electronic semiconductor components in all types of solid-state services.

Some common causes for voltages spikes in the power line are: Lightning strikes near power lines beyond the transformer, switching appliances on and off within the home (i.e. air conditioners, oil-burner furnaces), and utility power switching at the central station. LineGard suppressors act as a "shock absorber" by limiting those voltage spikes without interfering with normal current flow.

Three models available are: LG-10 wall plug-in unit with six U-ground outlets,

(Continued on page 13)

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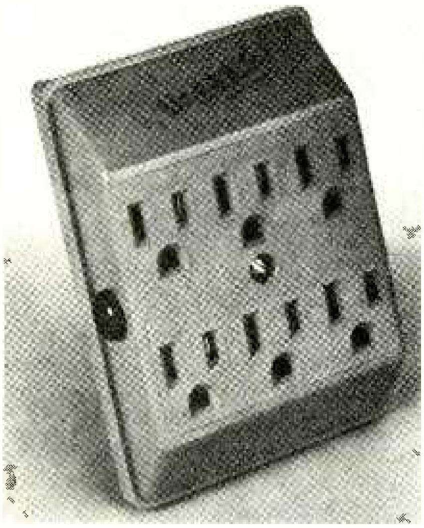
NEW PRODUCTS

(Continued from page 11)

pilot light constantly on—shuts off when overloaded to indicate filter not operating, internal overload protection—suggested list price is $16.95; LG-20 9¾-inch strip with four U-ground outlets, on/off switch with pilot light, 6-foot cord with three-prong grounding plug, push-to-reset circuit breaker protects against power overloads—suggested list price is $34.95; and LG30 console unit with four U-ground outlets, each set of two outlets (one duplex) is controlled by an individual on/off switch with pilot light, 6-foot cord with three-prong grounding plug, circuit-breaker protection—suggested list price is $59.95.

LineGard is sold nationally through hardware and home-center stores and computer retail stores. For more information, contact SGL Waber Electric, 300 Harvard Avenue, Westville, NJ 08093.



CIRCLE 747 ON FREE INFORMATION CARD

Preamp for Digital Audio Playback

Soundcraftsmen has introduced a new Straight-Line Preamplifier, the DX4000, designed expressly to maximize the performance potential of Compact Disc program material.

Included in the DX4000 are special high-overload inputs for CD player, phono, tuner and the audio portion of a video program. Three tape decks are accommodated, with cross-dubbing capabilities. Three external signal processor loops, a subsonic filter and a mono A+B switch make up the electronic "patch-bay" which occupies the center of the DX4000's front panel. Any combination of these functions may be routed to a tape recorder with the push of a button; no cable-switching is required.

CIRCLE 748 ON FREE INFORMATION CARD

The DX4000 features a standard rack-mountable front panel finished in charcoal epoxy power coat for extreme durability. Genuine walnut or oak side panels are available at extra cost. The DX4000 retails for $339.00. Available nationally at audio outlets. For specifications, write to Soundcraftsmen, 2200 South Ritchey, Santa Ana, CA 92705. **SP**

Jensen on DX'ing

How to break the shortwave language barrier!

WHEN IT COMES TO ANYTHING OTHER than *English*, it's all *Greek* to me!

That seems to be the feeling of many shortwave listeners (SWL'ers). Fortunately, there are scores of foreign shortwave stations that broadcast in English. So most DX'ers cut their teeth on the English-language programs beamed here by major international broadcasters around the world.

But they represent only a fraction of the stations on the shortwave bands. And you automatically dial out any station not broadcasting in the *big E*, you're unnecessarily limiting your listening adventures!

If you're a serious DX'er, sooner or later you'll want to tune in those stations which broadcast in other languages, obtain meaningful reports, and be able to obtain colorful QSL's for your effort. It's not all that difficult, either.

Language Barrier

I'm not suggesting you can become a linguist overnight—or even one at all. If you want to learn to speak another foreign-language or two, more power to you. But, frankly, you don't even have to know very much of another language for DX'ing purposes.

It's not necessary to be fluent in a language to be able to pick out key words that will allow you to identify the station you're hearing, and comprehend at least a little bit of its programming.

There are hundreds of different languages and dialects to be heard on shortwave. Most Latin American countries use Spanish. Brazil, which uses Portuguese, is the exception. In much of Africa, French is an important tongue, as is Swahili. Arabic programming is aired by stations in North Africa and the Middle East. Chinese is the language of hundreds of millions of radio listeners in Asia. Scores of languages and dialects are used by Soviet stations, both for foreign and internal radio transmissions.

A good place to start, even before you learn a single word in a foreign language, is with the *sound* of the various languages. The *Voice of America*'s foreign language broadcasts offer a good opportunity simply to listen and thus familiarize yourself with the *basic* sounds of different languages.

With some time and effort, you'll come to learn the basic sounds of the various languages--which ones sound soft and musical, which ones harsh and gutteral. You'll come to recognize certain language groupings by *sound*: the Romance languages, the Germanic-Nordic grouping, the Slavic tongues, the sing-song tonal languages of Asia.

Repeated listening will sharpen your ears. You'll learn to distinguish Spanish from Portuguese, German from Dutch, even if you don't know a word in any of them.

But, actually, you *will* be picking up a few words as you go along. The words you should concentrate on, at least initially, are those often heard as part of a station's identification announcements.

In both Spanish and Portuguese, for example, you may hear the word *transmite*—pronounced with a long *A* sound for the last syllable. It means just what you probably think it does—transmits. Part of the Portuguese-language identification of the government station at Luanda, Angola in southern Africa includes: "...*transmite a Radio Nacional*."

Spanish-language stations often identify with a phrase beginning with the words, "*Esta es*...". In translation that means, "*This is*...", and is followed by the name of the station.

In French, the equivalent to the Spanish *Esta es* is *ici*. The governmental station of the former French outpost in Africa, the Ivory Coast, identifies as "*Ici Abidjan*, (the capital city) *Radiodiffusion Ivoirenne*."

You'll find other useful *radio words* in foreign languages. In Spanish-speaking Latin American stations, frequencies will be announced in *kilociclos* (kil-o-SEEK-lohs). German-speaking stations generally refer to *kilohertz*, a term now common in English, too. In Spanish, the words *onda corta* mean shortwave.

Words that mean *this is* or *Here is*

(*Continued on page 97*)

SHORTWAVE LISTENING has been called *armchair traveling*, because radio makes it possible to *visi* exotic spots without ever leaving home. But DX'ing also can spur one's interest to actually see those places. Australian DX'er David Foster has traveled extensively in Indonesia, one of the most *radio-active* (in Hertzs, not Curies) countries of the world. Here David perches on a milepost, 100 kilometers from the major Indonesian city of Ujung Pandang.

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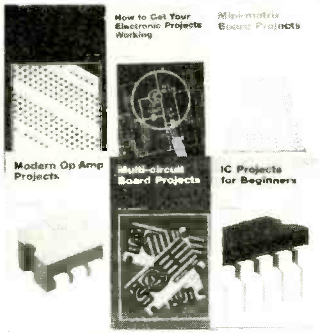

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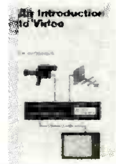

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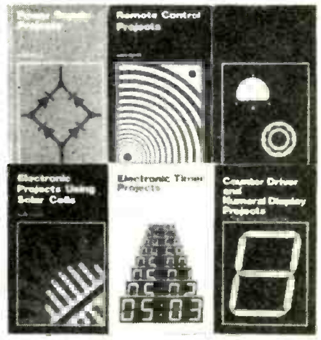

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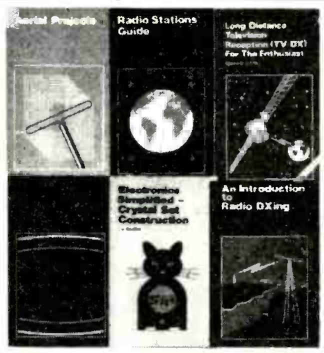

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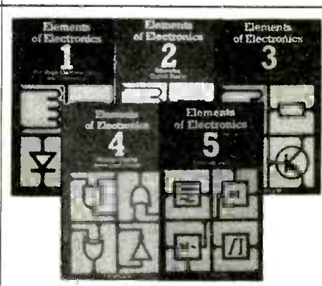

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Friedman on COMPUTERS

Small Computers For Big Jobs.

BY NOW IT'S ALMOST ENGRAVED IN stone that if you want a personal computer for business use—it's an IBM, or, at the very least, a computer that's software-compatible with IBM. The reason, of course, is that virtually all the new and super-colossal software is written first for the IBM—because that's where the sales are.

Unfortunately, not everyone can afford the $3000 and more that an IBM system will cost when the printer and software are added to the base price. Then again, there are thousand of folks who have no need for a business system. In fact, virtually all home and family needs can be met for well under $1000, often as low as $100; and many small *garage* and *kitchen table* part-time enterprises can also get by with an inexpensive personal computer. That's because the budget-priced software for those machines is quite good within their inherent limitations. Such as what limitations?

For one, a home-and-family computer can accomodate a mailing list of about 1000 names; a larger list needs a larger computer.

For another, accounts payable and receivable for a few hundred accounts is also within the range of budget software and hardware, as is an inventory of a thousand of so items. If your enterprise is larger, start thinking IBM.

First there's ADAM

But let's get back to more typical home-and-family applications. Consider for a moment the most touted use for a home and family computer: *word processing*. It improves the classwork for students of all ages, increases productivity of small businesses, and is the key to much of the newer database (electronic files) software. Well, for about $700 you can get Coleco's ADAM computer, which comes complete with a daisy wheel (fully formed characters) printer. It comes up as a word processor when power is first turned on, and the keyboard has specific word-processing function keys. In fact, BASIC, which is the usual *power up* function, must be loaded in from a digital cassette tape.

Unlike many low-cost audio cassette tape computer storage systems, the ADAM's digital system is extremely fast. All in all, a great combination for home and family where word processing and learning/using BASIC is important.

While there is virtually nothing available in third-party or small-business software at present, as with all other computers, users should soon be flooding the market with everything from mailing lists to electronic spreadsheets.

If you have to do your personal computing at rock-bottom cost, there's a lot of decent discontinued hardware in the marketplace; but you must be extra careful, because the availability of peripherals and software for discontinued hardware is shrinking. When the time comes to upgrade, there might not be any peripherals around, so assume that any discontinued hardware is a *terminal* purchase—*terminal* meaning no further expansion.

Time for Timex

If you're looking to spend the absolute minimum, try to locate a Timex 1000—which originally sold for $100. The Timex had a lot of limitations, among them a membrane keyboard (no real keys) and only 2K of RAM. But the BASIC is excellent, and it has single-key entry of BASIC commands. Also, the Timex has standard phono-jack connections for a cassette recorder (for saving and loading programs). At last look, those computers were selling for as low as $29 in a kit that included the formerly optional 16K RAM expansion module and a few game programs. There is probably no better buy for someone who just wants to learn something about programming.

Texas is bigger

For the more advanced programming student needing a standard keyboard and a decent amount of memory and color graphics, try to locate a Texas Instruments 99/4A. Though discontinued, there were warehouses full, and they can be purchased for as little as $50. Most peripherals have been long sold out, so don't expect to easily locate a disk drive or a peripheral interface, or much "business" software. Also, you must purchase the 99/4A with the special *cassette recorder cable*. Without the cable there's no way to save your programs on cassette tape. (You can use any cassette recorder.)

Ahoy, Commodore

Another outstanding buy for the beginning programmer is the Commodore VIC-20, which can be purchased for as little as $89. It has MicroSoft BASIC (the best kind), and superb color graphics. It has a limited working memory (about 3K), but that is enough for many tightly written programs, and certainly enough to learn on. Again, you will need a cassette recorder to save the programs.

The VIC-20 requires a special dedicated recorder called a Datassette that sells for about $60. The Datassette recording system is deadly slow; a 3K program is about all it can handle in a reasonable period of time. If you plan on expanding the VIC-20, save your money and pur-

(Continued on page 18)

Printer Samples Available for Budget-priced Personal Computers.

This is standard matrix, often called "data processing mode." Notice the prominent appearance of the dots that form the characters.

This is super-enhanced matrix, a mode that fills in the dots with more dots. It is the kind of printing called "correspondence quality."

These fully formed characters are from a daisy wheel printer. This kind of printing is called "letter quality."

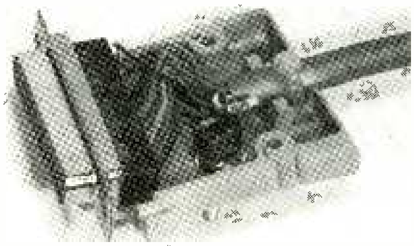
Testbench Tips

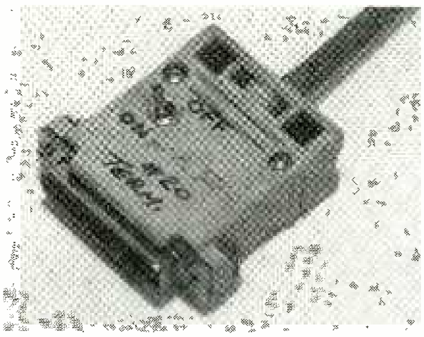
You earn $20 for each Tip

The very next time you come up with a simple, but clever, idea that helps you build a better project, or do a better job of installing, or testing, a project, let us know about it. Put your idea on paper (typewrite it), spelling out the details on one sheet. Take a black-and-white photo of the idea in action and send it to the Editor. (Color photos lose too much contrast.) If your tip is used in this column, you will receive a check for $20. Sorry. we will be unable to return your tip or photo, and all entries become the property of **Special Projects.** Send all mail to **Special Projects** Testbench Tips, Room 1101, 200 Park Avenue South, New York, New York 10003.

Making #20 Standard

While the #20 RS-232C terminal is supposed to be "standard," it *ain't* necessarily so. Sometimes the connection is needed for operation, other times it will lock out whatever you're using. Rather than bother with digging out a breakout box, or jumpers, or clip leads to experiment, simply make up a

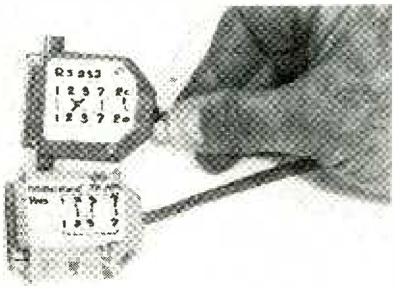




cable with a switch in the #20, or any other problem, connection. A subminiature switch (which requires very careful soldering) will just fit inside the large, grey, RS-232-connector covers if you squash bend the terminals down. If you don't have too many wires in the connecting cable you can fit two switches inside the cover. Make sure you label the "normal" condition of the switch.

Memory Label

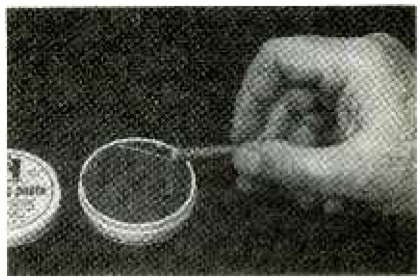
Some of the modern communications equipment and personal computers don't necessarily have the same connections on both ends. Then there's the problem of home-brew cables where you might have used only a few of some 25 or 36 possible terminals. To prevent confusion, and blown components, simply apply an adhesive la-



bel to the connector cover(s) and draw a pictorial of the actual terminal connections. If there's room, mark the specific equipment used with the cable. It will save a lot of headaches six months from now when you can't remember if the red dot on the blue connector is for the computer or the recorder.

Solder Slurper

Run out of solder wick? Tried the trick of using copper braid from coaxial cable, but found it wouldn't pick up any



solder? No reason it should, because the braid is too thick and the copper is

(Continued on page 98)

FRIEDMAND ON COMPUTERS

(Continued from page 16)

chase a larger computer to begin with; even a moderate expansion will cost you as much, or more than a "full featured" computer.

If you upgraded a VIC-20 with memory you would spend just about what it costs to buy a Commodore 64, so if you need a heavyweight in low-cost computing, it's best to start out with the Commodore 64. It features MicroSoft BASIC, superb color graphics, and a music generator—a dynamite package for about $200 (the discount-store price). Unfortunately, the Commodore 64 uses the same Datassette as the VIC-20, and cassette saves and loads seem to go on forever. For serious work the Commodore 64 must be used with a disk drive, which sells for about $225-$250 in discount stores.

Quite good home, family, and business software is available in disk format for the Commodore 64: everything from education and self-improvement for all ages, to program generators which actually write programs from database layouts you draw on the screen, to financial planning, to accounting and bookkeeping.

Bear in mind, however, that Commodore's disk system is serial, and it's relatively slow compared to most other disk systems. For example, the same general kind of financial program that loads in 13 seconds on a Radio Shack computer takes 53 seconds from the Commodore 64's disk. While not an important consideration for home/family/small-business use, disk-access time can be a limitation when large amounts of data are being processed.

There are ways around the disk speed, however. Like the VIC-20, the Commodore 64 accepts plug-in ROM program cartridges, which are "up and running" the instant the computer is turned on. As time goes on, it's expected that more and more sophisticated software, such as word processors, will be made available as a cartridge.

Go Color

If you need to get into computing NOW, and you're certain that you must eventually upgrade to a larger system—perhaps for your part-time business—but you have only enough funds to start small, then the Radio Shack Color Computer (CoCo) might be the way to go. For approximately $160 you can start out with a proven reliable machine that can be user-expanded to 64K, and which has a relatively high-speed cassette data storage system that is suitable for smaller word processing and business software.

The CoCo's optional disk system is also relatively high speed. As for printers, it will accommodate a broad range, from the least expensive matrix type to a professional-quality daisy wheel. Most important, there is an exceptionally broad range of software of every kind, available in plug-in ROM program cartridge, cassette tape, and disk.

While it probably makes no difference what computer is used for general family applications, the CoCo has the best potential for low-cost business use.

Get Started

Regardless how you choose to start out in personal computing, the main point is that you must start out *now!* If you're a student, computer literacy is expected from elementary school clear through high school to postgraduate studies or training. If you're looking to upgrade your skills or employment, virtually every job—from entry level to supervisor of anything—requires a familiarity with computers. *—Herb Friedman*

We talked about the Timex 1000 (keyboard unit at left) on page 16, and shown here are other Timex products. The 2000 is the keyboard unit at right.

TESLA'S COIL

RONALD IANNINI

Put together this resonant, high-frequency transformer and discover unusual effects that occur! Insulators are no longer insulators. Ordinary light bulbs glow a pale blue when off. See an "ion" windmill rotate.

TESLA COIL IS A MOST FASCINATING ELECTRICAL-DISPLAY device to see in operation. A large unit can produce a continuous spark of a length exceeding the height of the coil. Electric discharges simulating lightning bolts will produce cracks of noise louder than a rifle shot. Those sparks, as well as being highly impressive and attention-getting, produce bizarre effects in most common materials. For example, wood may explode into splinters or be made to glow with an eerie, reddish light from within. Common electrical insulating materials seem to be useless against that energy. Light bulbs light without wires when sparks and corona, in the form of St. Elmo's fire, occurs within proximity of the device. The coil's high-energy electric and magnetic fields render electronic equipment useless. Phenomena not normally associated with standard high-voltage electricity becomes apparent in the form of many other weird and bizarre effects.

All those unusual electrical phenomena can be displayed at home or school by building Tesla's coil from the plans in this article.

Theory

Tesla's coil is a high-frequency, resonant transformer. It differs from a conventional transformer in that the voltage and current relationships between primary and secondary windings are independent of turns ratios. A working apparatus basically consists of a secondary winding, LS1, and a primary winding, LP1. (Symbols used in this article coinside with those used by the author in a kit of parts he is supplying. Refer to the Parts List.) It is obvious that the primary circuit is capacitance-dominant, and tuning the primary circuit via taps along the primary coil does not alter the frequency by as

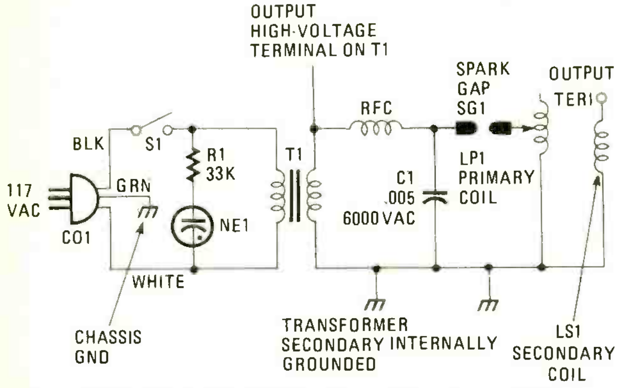


FIG 1—SCHEMATIC DIAGRAM of the high-voltage coil has not changed much from the days of its inventor—Nicol Tesla.

much as one would expect. However, that relatively fine tuning of the primary circuit to the secondary circuit is mandatory for proper operation. Force driving (untuned) the secondary coil will produce hot spots and interwinding breakdown.

Build Your Own Tesla Coil

This article tells you how to construct a device using a step-up transformer that will typically produce 6000 volts at 20 mA, powered from the 117-volt AC line. That voltage-current combination can kill an adult person, so extreme caution is urged when powering up the circuit and when working on the device after it has been used. The least that the voltage-current combination can produce a painful shock. If you are a minor, or a person inexperienced in handling very-high-voltage circuits, construct and operate the device with some experienced help. Safety rules should be followed at all times. The device also produces ozone—therefore, use it in a well ventilated area. Do not use for prolonged periods of time; 30 seconds at any one time is ample for any demonstration. Avoid eye exposure to the spark gap without ample protection such as safety glasses, shielding, etc.

The device, when constructed as shown, can develop voltages up to and in excess of 250,000 volts AC. That voltage will cause a gas-discharge lamp—such as a regular household fluorescent lamp—to glow up to a distance of several feet from the unit. The high-voltage center coil terminal can actually be touched with a piece of metal held securely in the demonstrator's hand, creating quite a conversation piece.

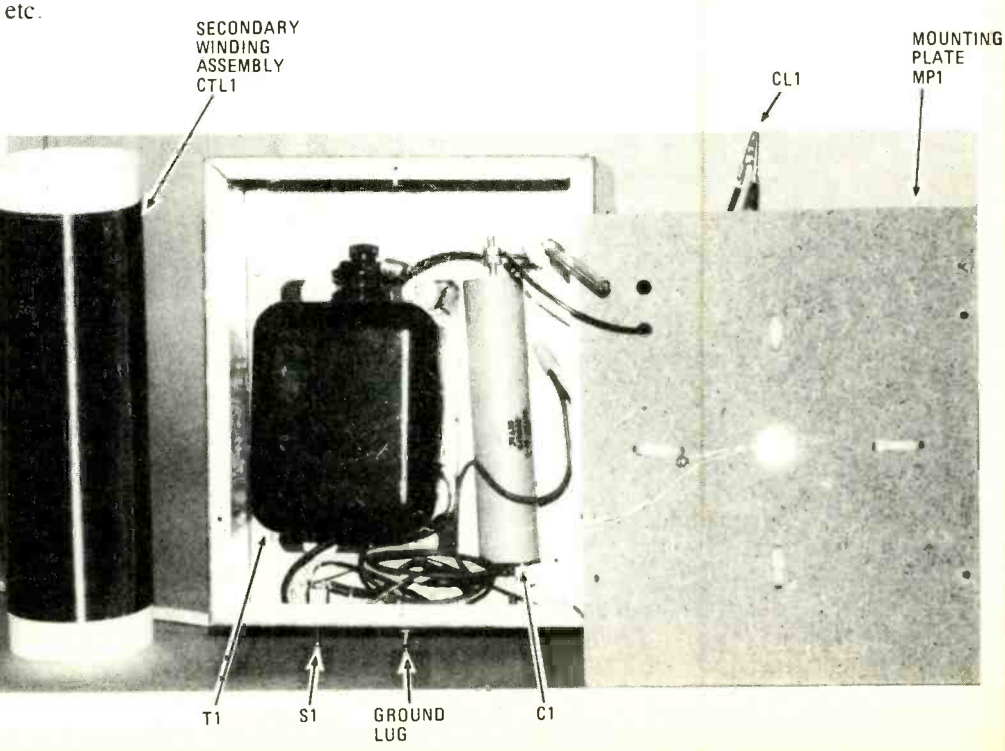
The unit can be used for exciting all types of gas discharge tubes, X-ray tubes, plucker tubes, etc. It demonstrates corona, St. Elmo's fire, and the effect of high voltage on many different types of materials. On a good dry day, with the device properly adjusted, it is possible to produce sparks 10 to 12 inches in length. It is designed for the experimenter who wishes to explore the effects of high-frequency, high-voltage energy.

Circuit Theory

The Tesla's Coil circuit (see Fig. 1) consists of a secondary coil LP2 containing approximately 500 turns that are wound tight on a PVC pipe form that is 12-inches long and has an outside diameter of 3.5 inches. The coil possesses an inherent resonant frequency, determined by its inductance and capacity. A primary circuit, consisting of a drive coil LP1 and capacitor C1 are impulse driven by a spark gap, SG1. The primary circuit should also have a resonant frequency equal to that of the secondary coil, LS1, for maximum performance. It is possible to force LS1 to produce some high voltage with less output current, but the results during demonstrations will be less spectacular. The output voltage of the device is dependent on the ratio of Q between those two coils.

The primary coil, LP1, has an adjustable tap that allows for fine tuning. It should be noted that it does not take much in the way of added capacitance to the secondary winding, LS1, to alter its resonance point. Even a change in the output terminal may require readjustment of the tap on LP1.

Transformer T1 supplies the necessary high voltage to drive an arc across the spark gap, SG1 (see Fig. 1). It is rated at 6000 volts AC at 23 mA. Those are optimum maximum



A PEEK INSIDE the sheet-metal box shows high-voltage transformer T1 mounted at the bottom with high-voltage capacitor C1 near by to avoid a long lead between the two parts. The bottom of the mounting plate is shown. The secondary-winding assembly is shown completed. Handle this coil with care. Do not nick or mar the tight-wound coils.

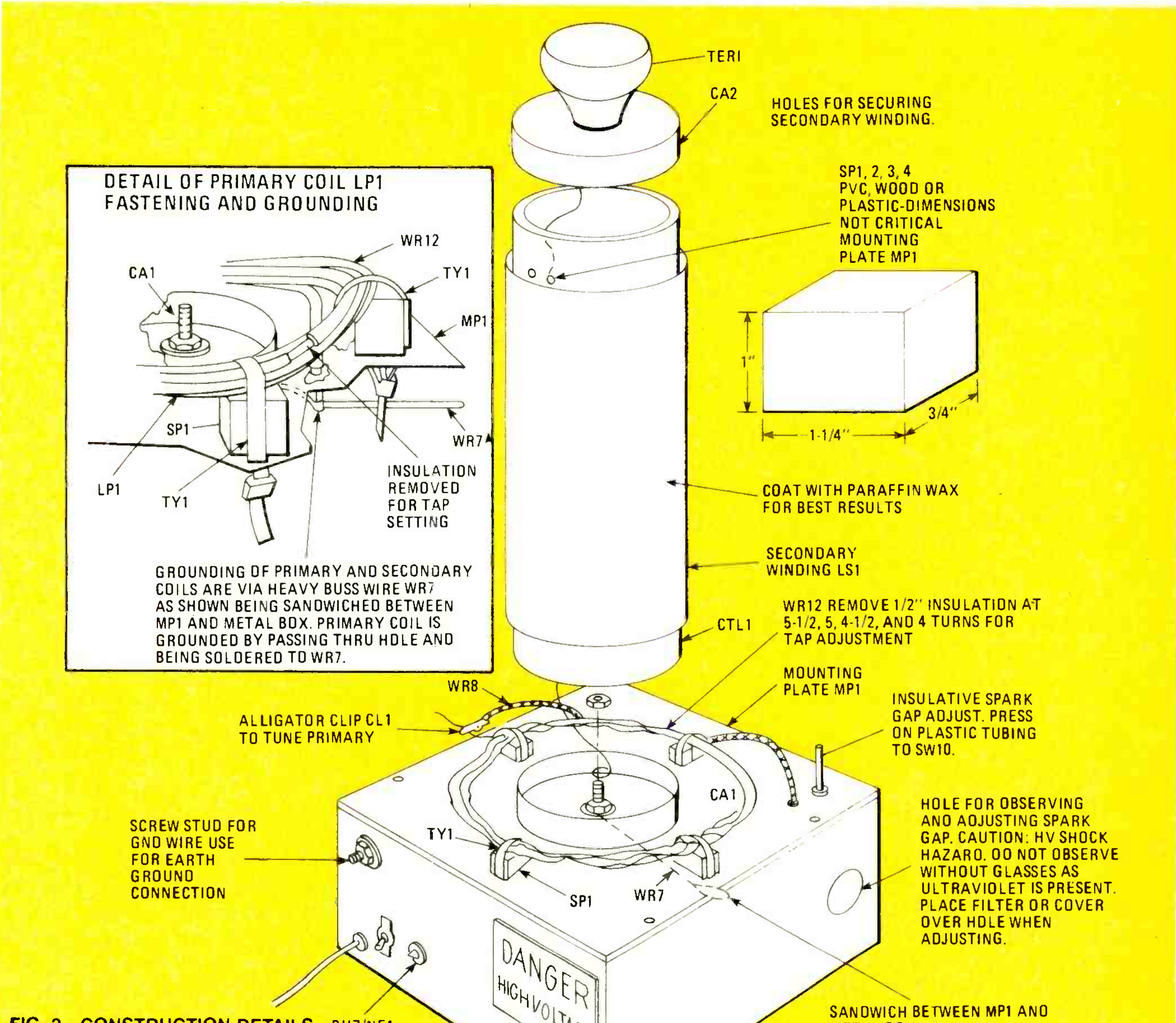


FIG. 2—CONSTRUCTION DETAILS for Tesla's Coil that are related to item mounted on mounting plate MP1. Do to the nature of high-voltage arcing, neatness is very important. Refer to the photos during assembly.

values that will not stress the circuit's components and insulation. That voltage charges the primary storage capacitor, C1, to a voltage where it fires the spark gap (SG1), producing an impulse of current through the primary coil, LP1, where oscillations take place. The frequency is determined by the inductance and capacity values of the primary circuit. Voltage output of the secondary coil, L2, is usually approximately equal to;

$$V_2 = (C_1 \times V_1)/C_2$$

where C_1 is the primary storage capacity, V_1 is the spark-gap discharge voltage, and C_2 is the secondary-coil capacitance (usually relatively small). Another way of expressing that relation is that the output voltage is dependent on input-drive voltage times the ratio of primary Q to secondary Q.

Construction

Please note that substitution of certain parts that may be made by the builder may increase or decrease the performance of Tesla's Coil. Refer to Fig. 2 for construction details.

Wind 10 inches of #24 magnet wire (WR13) on coil form (CTL1). Leave ¾- to 1-inch space at top and bottom on each end of the coil form. Fasten wires by threading them through small holes in coil form. Leave 12-inch leads. Coil form must be dry and clean. Varnish, dope, or coat the finished winding with paraffin wax several times to seal the winding against moisture and assist in holding it in place. Secondary winding LS1 must be neat and tight. Avoid kinks and overlaps as that will seriously affect coil performance.

The best way to wind coil LS1 is with another person who uses a broomstick as a shaft, and carefully dispensing the wire as needed. Keep wire taut. Winding should be approximately 45 turns-per-inch for a total height of 10 inches using less than 500 feet of wire. The finished winding is secured to mounting plate (MP1) via plastic cap (CA1).

Cut 10 feet of #12 wire and form into a coi, WR12, of 6 turns with a 6-inch diameter as shown in Fig. 2. Hold together with tape. Fabricate four pieces of dry wood, or plastic, for spacer SP1. Those blocks are 1¼ × ¾ × 1 inch for mounting

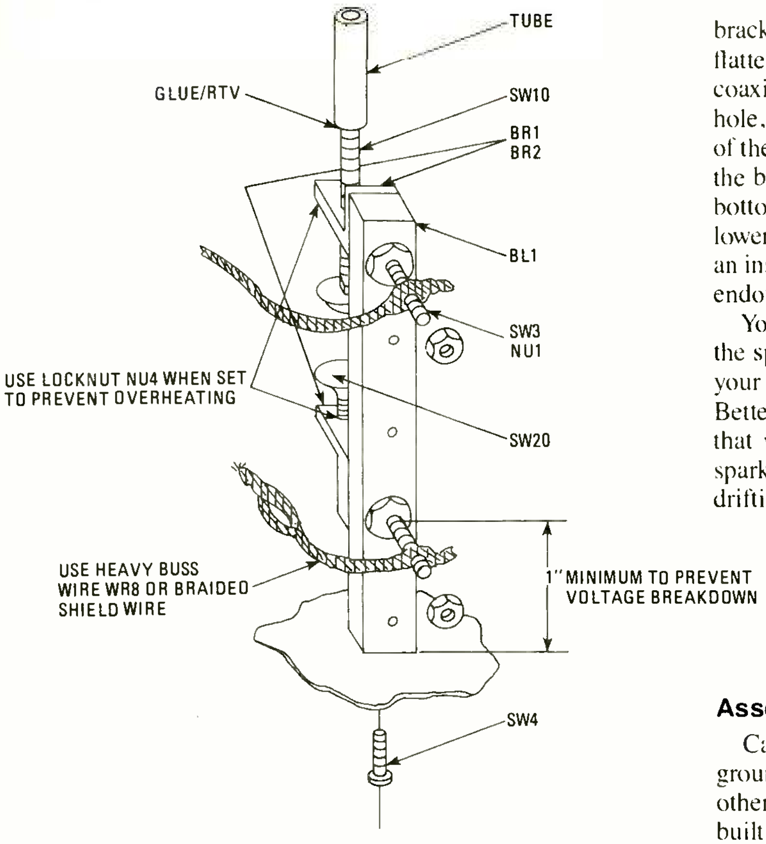


FIG. 3—THE SPARK-GAP ASSEMBLY is very critical to the operation of Tesla's Coil. Poor construction practices here will result in arc-over, and reduced spark length, if any spark at all!

and securing primary coil (LP1). Use plastic tie wraps to secure blocks (SP1) and coil simultaneously to mounting plate (MP1) as shown in the inset drawing in Fig. 2.

Spark Gap Details

To construct the spark-gap assembly, SG1, (see Fig. 3) fabricate a 3-inch teflon block (BL1) as shown. Note angle brackets BR1 and BR2 for attaching SW10 and SW20 spark-gap screws. Those brackets should be tapped for ¼-20 screws on one end. Leave enough spacing between the bottom bracket and chassis to prevent voltage breakdown. Note the flattened section of braided cable WR8 (shield salvaged from coaxial cable) with holes for attaching to screws. To make the hole, push an awl point through the center of the flattened part of the braided cable. Be sure to use a nut as a lock nut to *lock* the bottom screw (used as part as the spark gap) against the bottom bracket. The top screw is allowed to turn, raising and lowering the screw, providing spark-gap adjustment. Attach an insulating shaft of plastic tubing by pressing on to the stud endof that screw.

You may want to cut out a window in the box for observing the spark gap. Cover hole with glass, plastic etc., to protect your eyes from the ultraviolet rays generated by the spark gap. Better still—attach a cover plate, possibly hinged, to cover that viewing port. For continued use, it is advised to lock spark-gap screw SW10 by means of a lock nut to prevent drifting of the screw.

Assembly Inside the Box

Capacitor C1 is mounted by means of a bracket on the grounded end of the spark-gap assembly (see Fig. 4). The other end is supported via several pieces of double-sided tape built up to the correct thickness for proper securing. Only one capacitor is shown. The remaining assembly is illustrated in the drawings with attention being given to proper positioning and spacing of the high-voltage components. The mounting base (MP1) must be non-metallic. Dimensions of metal enclosure are not critical as long as there is ample spacing. Use sheet metal screws, rivets, etc., for putting enclosure together. Use standard wiring and assembly techniques.

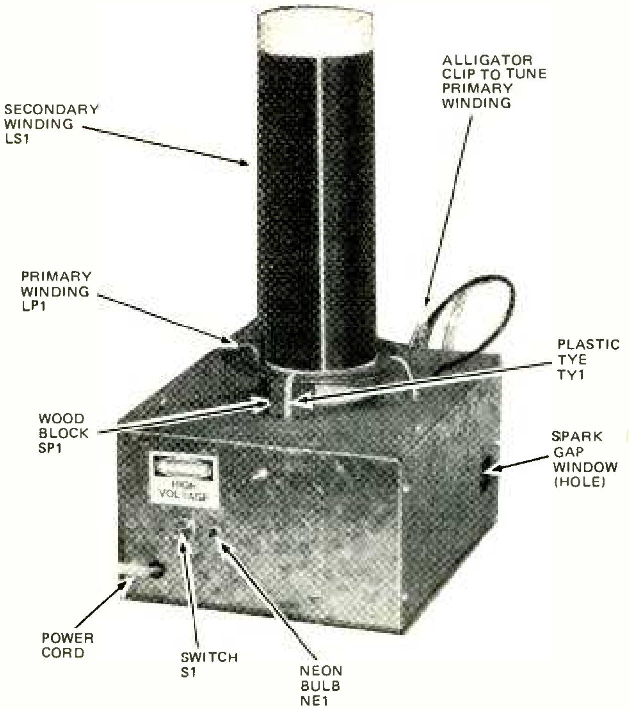
A convenient output terminal for secondary coil LS1 can be a smooth doorknob attached via a bolt through CA2. That also looks good and gives the coil a finished look.

When firing up your coil, start with the spark gap set at 2 turns from "closed", and adjustment tap at maximum inductance. Note that that lead also contributes to total inductance when routed as shown. (Same direction as turns of primary coil.) It should be possible with that coil to easily obtain 10 to 12-inch streamers when properly adjusted. Careful adjustment of the tap location and gap adjustment will greatly enhance performance. When operating for a prolonged period, always note potential breakdown points occurring—indicated by heavy corona or premature sparking. Those points must be corrected or a burning tracking condition will result.

Experiments

Before you begin, adjust the Tesla's Coil by suspending a grounded metallic object above the device. Start with three inches of separation, and make adjustments increasing separation until the optimum spark length is obtained. (Note: Grounding of the metallic object means connection to metal base).

The effect on human body by Tesla's Coil may cause a



HERE'S TESLA'S COIL as your project will look like when completed. The spark-gap window is required only when making initial adjustments. Cover this hole to prevent harmful ultraviolet rays from exiting.

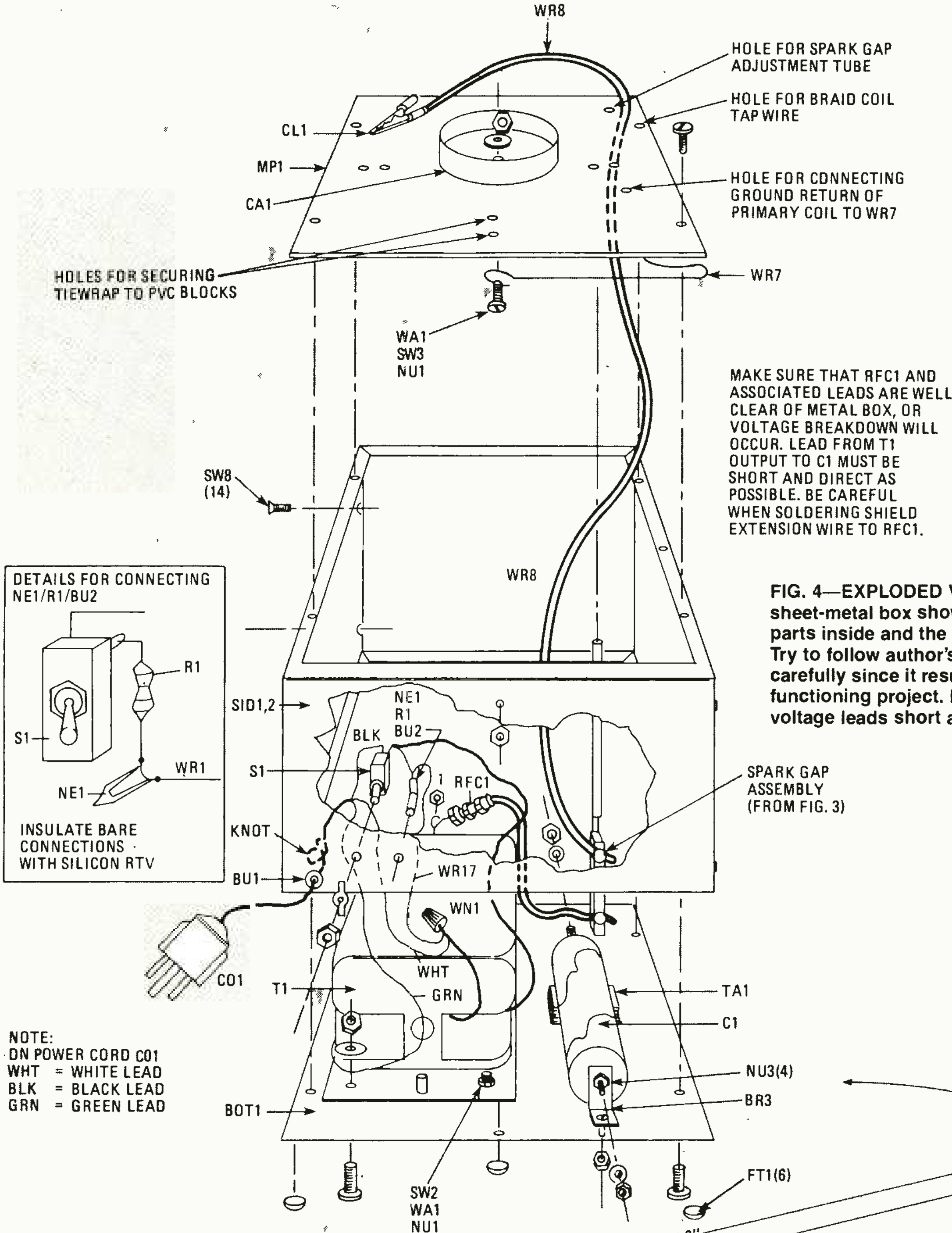


FIG. 4—EXPLODED VIEW of the sheet-metal box showing location of parts inside and the related wiring. Try to follow author's layout carefully since it results in a functioning project. Keep high-voltage leads short and straight.

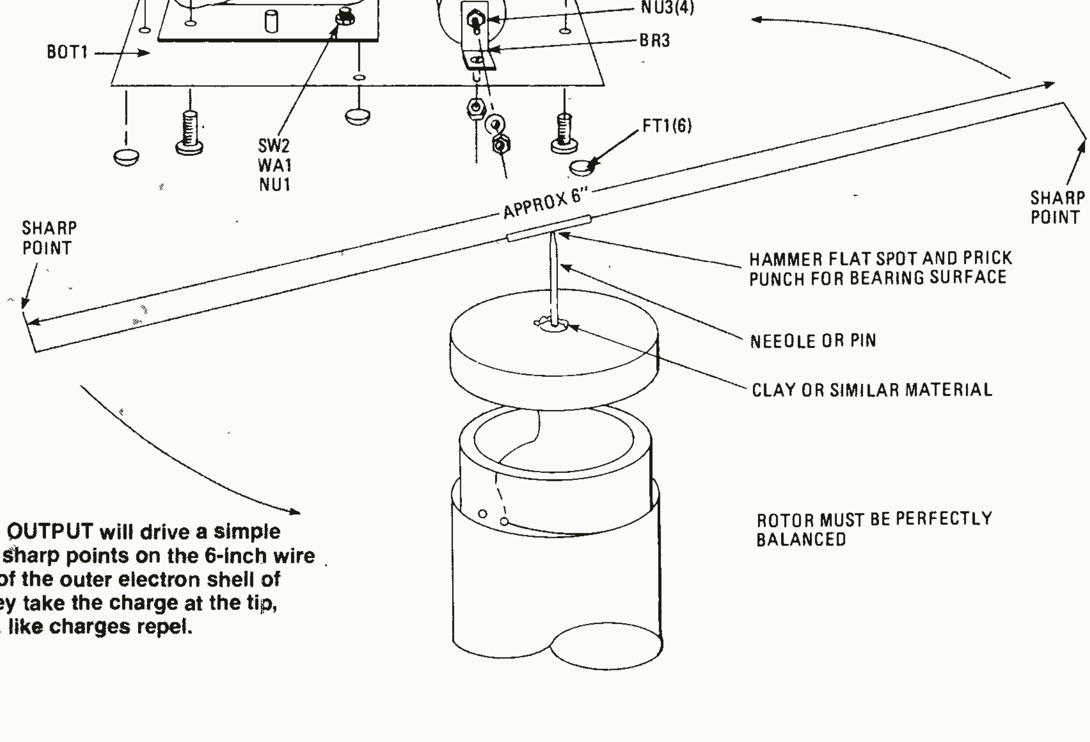


FIG. 5—THE COIL'S OUTPUT will drive a simple "ion" windmill. The sharp points on the 6-inch wire causes breakdown of the outer electron shell of atoms in the air. They take the charge at the tip, and, as we all know, like charges repel.

reflex secondary reaction even though it is painless. Hold a metal object tightly and advance to coil terminal. Note the painless, tingling sensation. Fake out your pals by letting them think it is really painful. That performance demonstrates the skin or surface effect of high-frequency electricity.

Place various objects on the top of the coil and note the effects of the high frequency electricity on insulating material. The sparks are not stopped by glass or other usual insulators. Experiment using objects such as light bulbs, bottles, glass, etc.

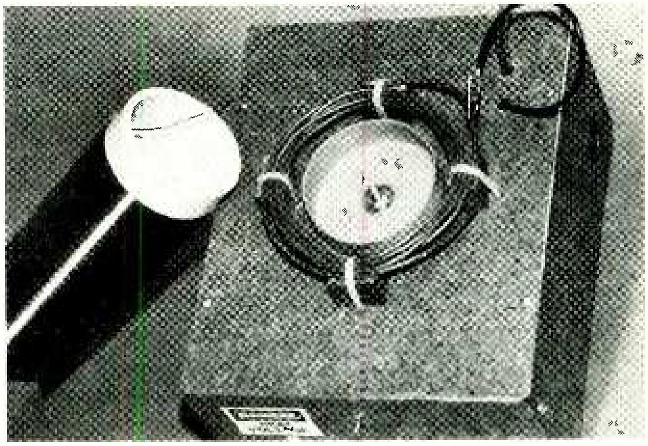
Place wood pieces, partial inslulators, about 12 × 1 × 3 inches and note red streaks and other bizarre phenomena occurring from within the piece.

Obtain a fluorescent lamp and allow it to come within several feet of Tesla's Coil. The bulb will glow and produce light without direct connection, clearly demonstrating the effects of the electric and magnetic fields on the gas that has been ionized. Note the distance from the coil from which the lamp will glow.

A neon lamp can be made to glow in the above experiment. Obtain other lamps and note the colors, distances, and other phenomena. The orindary light bulb will glow.

Induction fields are demonstrated by obtaining a small filament-type lamp, such as a flashlight bulb or something similar, and connecting it between a large 1½ to 2-inch diameter wire loop. The lamp will now light due to energy coupled by induction. You will note that current is required to light that type of lamp and is entirely different than the radiation field that ionizes and causes the gas lamps to glow.

Create special effects of pinwheels, color fires, etc. (see Fig. 5) by connecting pieces of nichrome wire to the top of



THE COIL ASSEMBLY fits neatly onto a plastic cap. The screw in the cap center locates and secures the cap. It also serves as a terminal to ground the coil's bottom end.

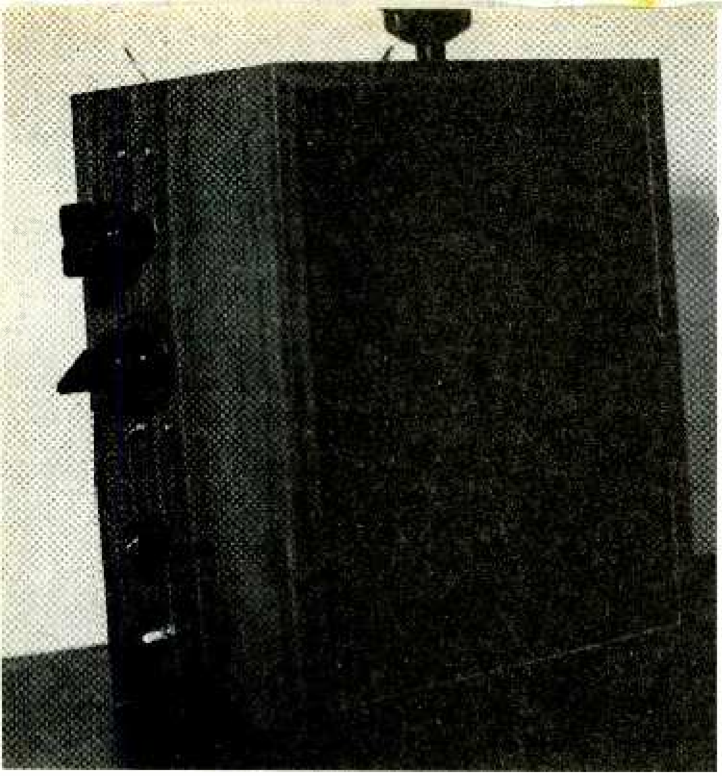
the coil. The rotor will rotate, creating a ring of fire. Try different types of rotors.

As above, you could fabricate an ion motor. It requires a carfully balanced rotor. Use a piece of #16 or #18 copper bus wire. The rotor will spin at high speeds if carefully balanced, demonstrating the principle ion propulsion.

In no way have we exhausted the various possibilites that Tesla's Coil may be used to demonstrate basic scientific principles and provide colorful, dynamic displays for the builder. Build our Tesla's Coil, and you'll never regret the hours of pleasure you'll obtain from it. **SP**

PARTS LIST FOR TESLA COIL

BL1—⅜ × ⅜ × 3-in. teflon block, or equivalent. Fabricated per Fig. 3
BOT1—9 × 11-in. #22 galvanized steel (See Fig. 4)
BR1,2—¾ × ¾ × ⅜-in. brass brackets (See Fig. 3)
BR3—1 × 2-in. #22 galvanized steel for holding C1
BU1—½-in. plastic bushing or clamp for line cord
BU2—⅜-in. plastic bushing
C1—.005-μF, 6000-VAC capacitor
CA1,2—3½-in. plastic caps to fit ends of CTL1
CL1—Alligator clip
CO1—3-wire #18 power-cord assembly with molded plug
CTL1—12-in. length of 3½ OD PVC to be 40 wound with 450 turns of #24 enameled wire (WR13)
FT1—6 stick-on rubber ft.
LAB1—Danger HV warning label
MP1—9 × 11-in. finished masonite (See Fig. 4)
NE1—Neon lamp with wire leads (no built-in resistor)
NU1–11 6-32 kep nuts
NU3–4 10-32 hex nuts
NU4—2 ¼ 20 hex nuts
R1—33,000-ohm, ¼-watt resistor
RFC1—2.5-MHz, RF choke—should have a high voltage rating
S1—20-A toggle switch
SID1,2—6½ × 20½ #22 gavanized steel sheets to make metal box (See Fig. 4 as 9 × 11 × 5½ box)
SP1-SP4—1¼ × ¾ × 1-in. insulating blocks fabricated per Fig. 2
SW3—4 6-32 × 1-in. panhead screws
SW2—5 6-32 × ½-in. panhead screws
SW4—#8 × ⅜ sheet-metal screw
SW8—14 #6 × ⅜ self-tapping, type-F screws
SW10,20—2 ¼-20 × 2-in. carriage bolts, preferably smooth brass heads
T1—6000-VAC, 23-mA ignition transformer
TA1—Two-sided tape
TER1—Smooth, brass doorknob for terminal (not included in kit below)
TUBE—3 × 3/16-in. ID flexible poly tube
TY1—4 8-in. nylon tyewraps for securing primary to spacers and MP1
WA1—5 flat, wide-shoulder washers
WN1—#3 small wire-nut
WR12—10-ft. length of #12 covered wire for forming primary winding PL1
WR13—500-ft. length of enameled wire
WR7—6-in. length of #16 buss wire
WR8—2-ft. length of ¼-in. braid wire
WR17—3-in. length of #24 precut lead



TV SOUND RECEIVER

Follow your favorite soap program or newscasts in a room away from the TV set, or out-of-doors with battery power at poolside, picnic ground, or ballpark!

STEVE PENCE

IF YOU HAVE A SOLID-STATE TELEVISION RECEIVER THAT IS soon to be thrown out, save the VHF and UHF tuners. Frequently, a TV receiver's high-voltage section, or picture tube, will go bad while the tuner is still in good condition. The cost of a repair to restoring that set will often be more the the cost of a new TV receiver (assuming a black-and-white set). With the project we are about to unveil, that old TV receiver won't be a total loss.

With the TV Sound Receiver plans presented here you can bypass the low-quality audio system found in most television sets and send the sound through your high-fidelity system. The resulting advantage is better sound and no internal connections to your TV.

You can even make the TV Sound Receiver portable, like a transistor radio, by adding batteries and a speaker. The project has its own audio-power amplifier for that purpose. You can listen to your favorite shows should you be in a situation where you can't watch the boob tube. During the past football season, the receiver was located in my work area and tuned to my favorite, but last-in-the-division, team. Whenever the locals had a long-yardage or scoring play, I'd dash from my desk to the color set to watch and cheer the replay.

The TV Sound Receiver could even make a great birthday or Christmas present for teenagers who like to listen to the video-music channels that have recently come on line.

Circuit Description

The TV sound receiver essentially duplicates the front end of a standard television receiver. A set of three chips made by Motorola is used to make up the video and sound IF amplifier and detector sections of the receiver (see Fig. 1).

The first stage, U1—a MC1350 video IF amplifier—accepts the 45-MHz output of the VHF tuner, which provides about 40 db of gain. In addition, U1 has provisions for an AGC input which will be discussed a little later

The output stage of that amplifier is rather broadly tuned with R2, C3, and the dual coil L1/L3. Normally, the coupling network between that and the next stage would be a little more complex. Since our primary purpose is to obtain good sound and not video, the requirements can be somewhat relaxed and the overall circuitry simplified.

Capacitor C5 couples the signal to the input of U2—an MC1330 low-level video detector. That stage is tuned to the video-carrier frequency by coil L4 and variable capacitor C6. The traditional diode peak detector has been dispensed with in that integrated circuit and replaced with a balanced-switching type demodulator.

There are several advantages to the balanced demodulator. Among them is the ability to detect very low signal levels and produce a very linear output. One of their disadvantages is susceptibility to overload, thus the need for clamping diode D1 (see Fig. 1). In any event, the output at pin 4 of that device contains two distinct signals in which we are interested: First, the 4.5-MHz difference signal that is produced by beating the sound carrier and video carrier in the detector; and second, the baseband video signal.

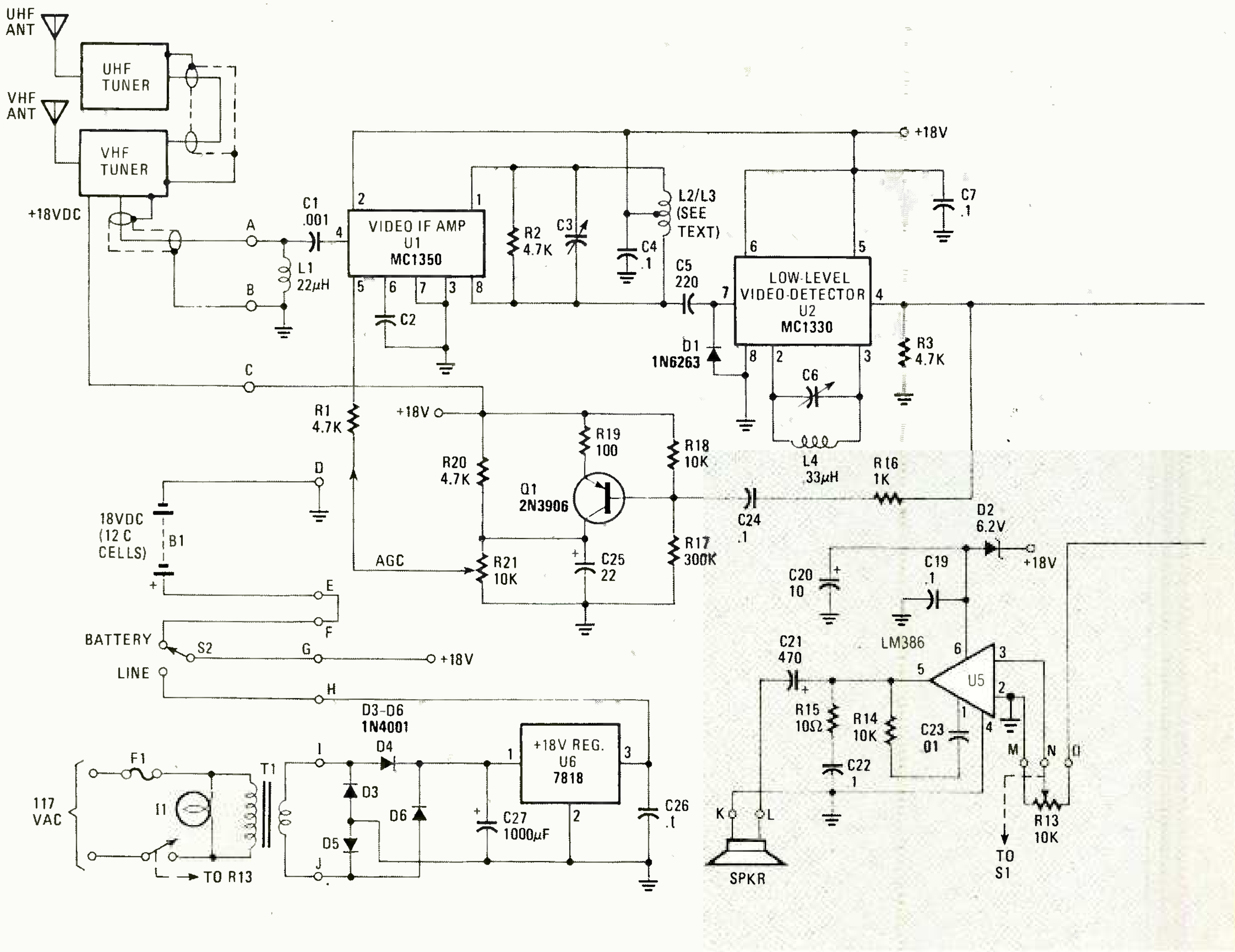
As stated before, the video signal is not our primary objective, but it is needed in order to extract an AGC signal. The detected sound signal cannot be used for that purpose because it is transmitted as a frequency-modulated carrier. That means that the sound amplitude is independent of carrier amplitude or signal strength.

The video signal, however, is transmitted as amplitude modulation and its level is, on the most part, directly proportional to signal strength. Therefore, the detected video is routed to transistor Q1. That stage is basically an amplifier that drives a lowpass filter/storage circuit. As the video-signal level increases, Q1 turns on harder and harder, charging up capacitor C25 to a higher voltage. That voltage is split off by variable resistor R19 and sent to the AGC input of U1.

As the AGC voltage increases, the gain of U1 is decreased. Conversely, as as the AGC voltage decreases, the gain of U1 increases, maintaining the video-output level constant.

Getting back to the output of U2, we also split off the 4.5-MHz difference signal and feed it to a ceramic, bandpass filter, X1. The ceramic filter acts like a high-Q, tuned circuit which filters out and passes to the next stage, the 4.5-MHz sound signal. Since X1 is pretuned to the proper frequency, adjustment is not required for alignment.

The next stage, U3, consists of a MC1358 sound, IF-



amplifier/detector. U3 amplifies the 4.5-MHz sound signal and then performs the FM detection necessary to recover the audio signal.

The detector in U3 is tuned by C12 and L5. That IC uses a differential-peak detector and requires only one tuned circuit for alignment. As you can see in Fig. 1, the entire video and sound IF circuit is tuned with only three variable capacitors.

The recovered audio signal at pin 8 of U3 is next sent to U4, LM318, for further amplification. Chip U4 also provides a fairly low-output impedance with which to drive the next stage or the input to a stereo. Potentiometer R12 is a trimmer that can be used to set the line level sent to an external high-fidelity amplifier. That makes it easy to balance the output of the TV sound receiver with that of other sources of program audio. The LM386, U5, provides the audio-power gain needed to drive a loudspeaker, SPKR, when portable operation is desired.

Finding a Tuner

The most economical approach to obtaining a tuner is to get one from a junk TV. As far as the TV Sound Receiver is concerned it makes no difference whether it is a tuner from a black-and-white TV or from a color TV. The 45-MHz IF output is the same in either case.

You should not attempt to use a tuner which uses tubes, because the voltages needed to operate it would be far too high.

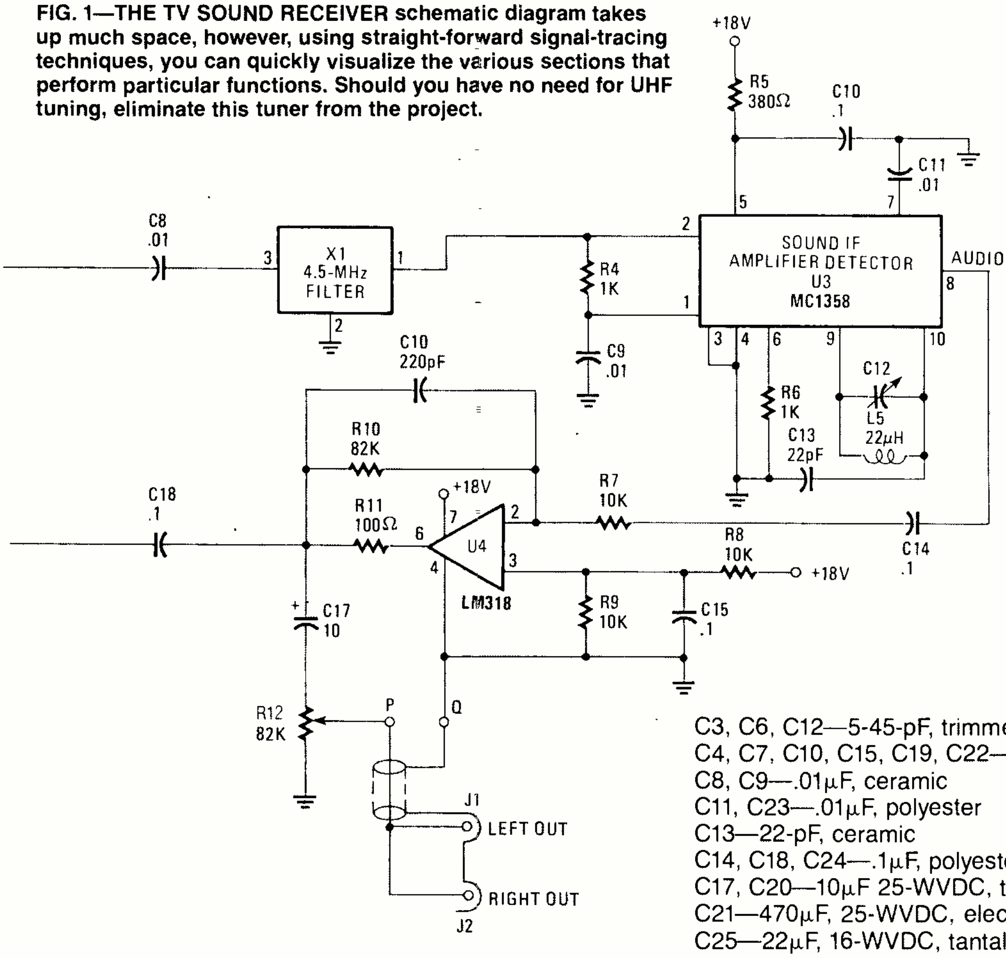
If at all possible, you should attempt to measure as many of the tuner's operating voltages as you can before removing it from the TV receiver. If you cannot obtain the operating voltages in that fashion, they can be found by referring to the Sams Photofact covering your particular TV receiver.

If the TV is still sufficiently functional, switch the tuner to a strong local station and adjust it for a normal picture and good sound. Now, do not change those settings and you will only have three things to adjust during alignment of the project. If you cannot do that, then you will have to hook the tuner's output to a functional TV receiver in order to preture it. That will be covered more thoroughly later, during the alignment instructions.

If a junk TV receiver is not available there are a number of mail-order firms that sell surplus tuners. Those are usually either VHF or UHF, seldom the combination of the two that would be available from a television receiver.

If your requirements are such that you only need a UHF tuner, it would probably be best to obtain the varactor type instead of the older mechanical variety. The varactor tuners use an RF amplifier for improved signal to noise characteristics. The mechanical UHF tuner's are designed to be used in conjuction with a VHF tuner. When the VHF tuner is set to its

FIG. 1—THE TV SOUND RECEIVER schematic diagram takes up much space, however, using straight-forward signal-tracing techniques, you can quickly visualize the various sections that perform particular functions. Should you have no need for UHF tuning, eliminate this tuner from the project.



PARTS LIST FOR TV SOUND RECEIVER

SEMICONDUCTORS
D1—1N6263 or MBD101 Schottky diode
D2—1N4735A 6.2-VDC Zener diode
D3,D4,D5,D6—1N4001
Q1—2N3906 NPN transistor
U1—MC1350 IF amplifier integrated circuit
U2—MC1330 video amplifier/detector integrated circuit
U3—MC1358 sound IF and detector integrated circuit
U4—LM318 operational amplifier integrated circuit
U5—LM386 audio power amplifier integrated circuit
U6—7818 +18-VDC regulator integrated circuit

RESISTORS
(All fixed resistors are rated at ¼-watt, 5% tolerance)
R1, R2, R3, R20—4700-ohm
R4, R6, R16—1000-ohm
R5—380-ohm
R7, R8, R9, R14, R18—10,000-ohm
R10—82,000-ohm
R11, R19—100-ohm
R12, R21—10,000-ohm, trimmer potentiometer
R13—10,000-ohm, volume-control power switch S1
R15—10-ohm
R17—300,000-ohm

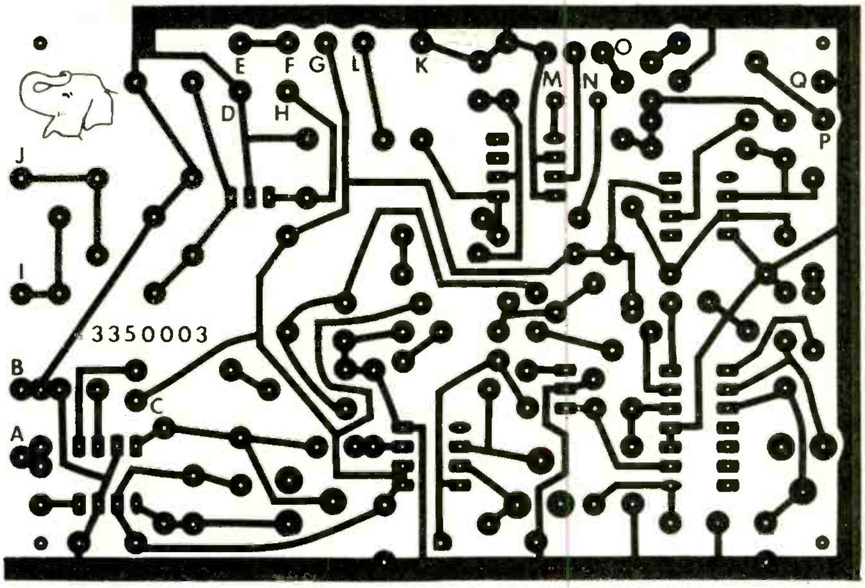
CAPACITORS
C1—.001μF, ceramic
C2, C5, C16—220-pF, ceramic
C3, C6, C12—5-45-pF, trimmer capacitor
C4, C7, C10, C15, C19, C22—.1μF, ceramic
C8, C9—.01μF, ceramic
C11, C23—.01μF, polyester
C13—22-pF, ceramic
C14, C18, C24—.1μF, polyester
C17, C20—10μF 25-WVDC, tantalum
C21—470μF, 25-WVDC, electrolytic with radial leads
C25—22μF, 16-WVDC, tantalum
C27—1000μF, 25-WVDC, electrolytic with radial leads

INDUCTORS
L1, L5—22μH, RF choke
L2, L3—Close wind two coils 7½-turns each on ¼-inch, non-inductive form. Requires 24-in. length of #22 enameled magnet wire
L4—.33μH, RF choke

ADDITIONAL PARTS AND MATERIALS
F1—.5-A fuse
I1—110-VAC pilot lamp
J1,J2—RCA phono jack
S2— spdt toggle
T1—Step-down power transformer: 117-VAC primary winding; 18-VAC, center-tapped, 300-mA secondary winding
X1—4.5-MHz ceramic filter (Radio Shack 272-1304)
1—Fuse holder
1—Printed-circuit board

WHERE TO BUY
The following items are available from Elephant Electronics Inc., P.O. Box 41770P, Phoenix, AZ 85080:
PC board only, $13.95;
Complete kit of all items listed above, $49.95.
Arizona residents please add 6% sales tax ($.85 for board and $3.00 for kit). Canadian orders, please make payment in U.S. funds. Allow 4 to 6 weeks for delivery.

FIG. 2—PRINTED-CIRCUIT BOARD for the TV Sound Receiver is shown here same size. Being relatively small in size compared to the inside of a speaker cabinet, mounting the printed-circuit board, tuners and controls in a cabinet presents no problems.



UHF position it is configured as a 45-MHz amplifier. That boosts the UHF tuner's signal by about 30 dB before it is applied to the IF strip. If you use an UHF tuner without its VHF counterpart, there may not be enough gain.

The varactor tuners are also available from a number of mail-order companies. Prices vary from about $10 to as much as $40, so shop around before you buy.

Construction

If you are not experienced at laying out and building RF circuitry, it is strongly advised that you use the printed-circuit foil pattern shown in Fig. 2. If you are not able to etch your own circuit board, one is available from the source given in the Parts List.

Before you begin construction, you must decide how the final project will be used. For example, if you are going to use it strictly as an audio source for your high-fidelity system, you will not need a speaker or the audio power amplifier, U5. You would be able to delete the volume control, R13, and all of the other components associated with U5. (See Fig. 1.)

The receiver could then be installed inside a low-profile cabinet that will blend in with the rest of your audio equipment.

With the author's prototype, on the other hand, it was desired that the unit also be portable and operate as a stand-alone receiver. The project was therefore installed inside a Radio Shack speaker cabinet, along with the tuner and battery pack.

Construction is started by first making your own printed-

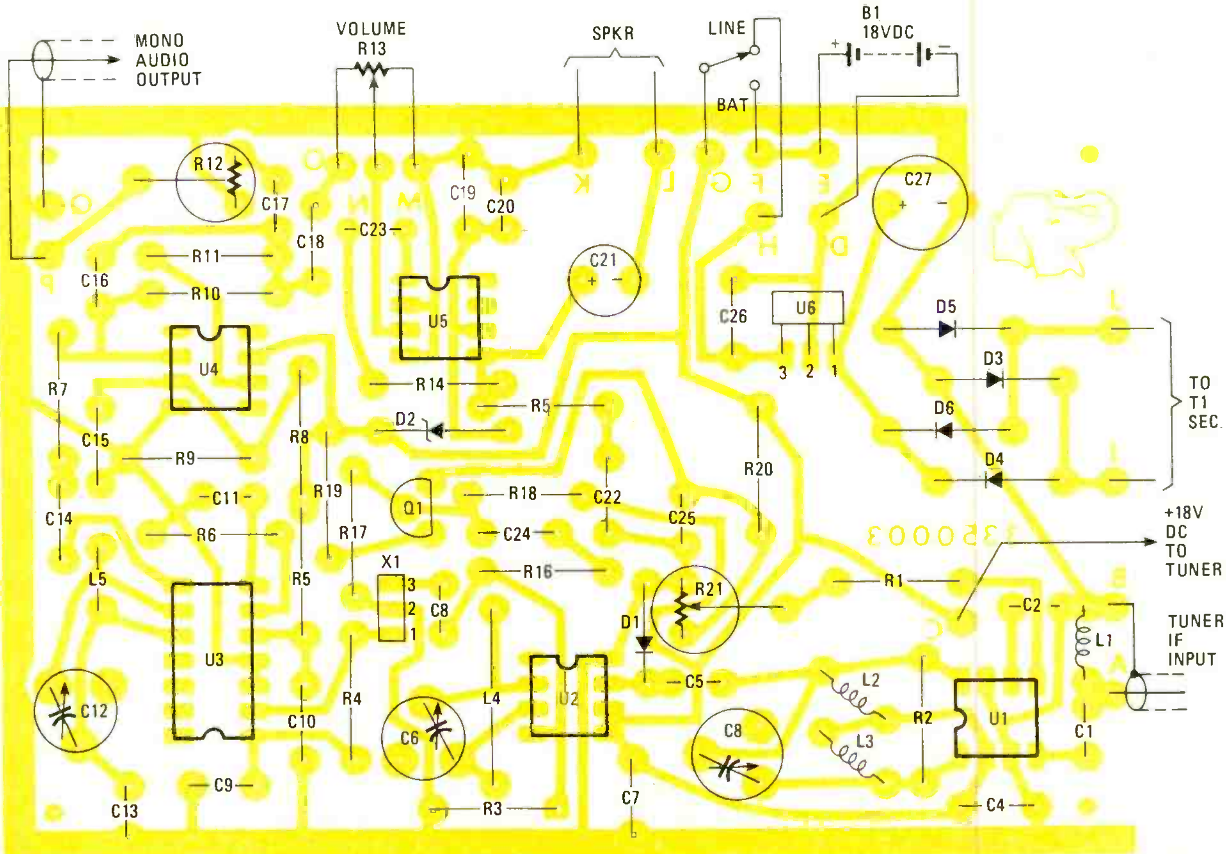
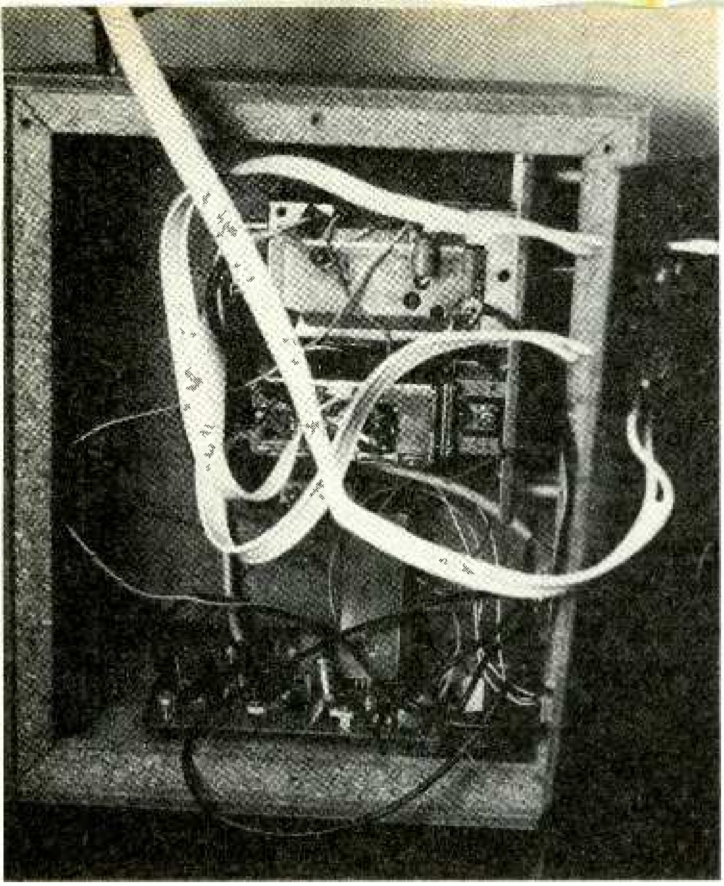


FIG. 3—THIS ENLARGED X-RAY VIEW of the TV Sound Receiver circuit board shows the circuit components mounted in place and the external connections that are required. You are dealing with TV IF signals, so be sure that your work is neat. Solder connections should be bright and clean.



circuit board from the foil diagram in Fig. 2 or purchasing an etched board from the supplier listed in the Parts list. Figure 3 illustrates where the parts are connected to the board. Make coil L2/3, actually two separate coils that when mounted on the printed-circuit board are wired as one center tapped coil. Refer to Fig. 4. They are made by close winding 7½ turns of #22 AWG magnet wire on a ¼ inch form. A ¼ inch drill bit makes an ideal form. Begin winding over the top unfluted section of the drill as shown in Fig. 4.

Next, continue to assemble the printed-circuit board following the parts layout of Fig. 3. That is most easily done by loading the low-profile components first, such as resistors and diodes. Place the board, component side up, on a piece of foam. Insert the components through the holes so that the leads stick into the foam. When you have several components installed, carefully pull the board away, flip it over, and set it back down. The foam will hold all of the parts firmly in place while you solder them. Clip the component leads short, and continue installing parts. Install progressively higher-profile parts until the board is completely loaded.

It is recommended that integrated-circuit sockets be used, because that will make any potential troubleshooting much easier later on. Be sure to observe the proper polarity and orientation of integrated-circuit chips, filter X1, capacitors, and diodes.

After the board-mounted components have been installed, you should add a heat sink to voltage-regulator U6. That need be nothing more than a couple of square inches of sheet metal or thin aluminum bolted to the metal tab. Use heat-sink compound to ensure efficient heat transfer.

Before mounting the board in its final resting place, install and solder the wires necessary to interconnect the board to the external controls, etc. Follow the interconnection details given in the schematic diagram (Fig. 1) and X-ray view of the printed-circuit board (Fig. 3).

The coaxial cable that connects the IF amplifier to the tuner should be the RG174U type. That particular coaxial cable is

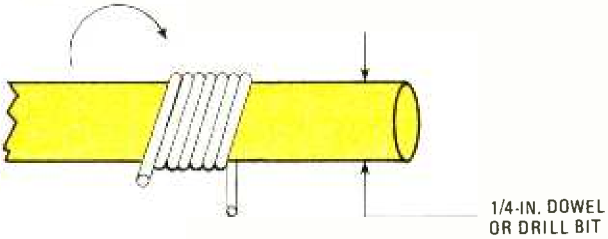


FIG. 4—TWO COILS, L2 and L3 are hand wound by the experimenter on a ¼-in. form. Use #22 AWG enameled magnet wire and wind 7½ turns for each. Refer to text.

thin, only a tenth-of-an-inch thick, and is easy to work with. It is also the proper impedance and causes less signal loss than the audio type of coaxial cable. An alternative is to salvage the coaxial cable used to interconnect the tuner and circuit board in the discarded TV receiver.

Do not solder the coaxial cable to the tuner at that time unless you were able to pretune your TV tuner, as explained earlier. If you were not able to do that, you will have to do it next, as explained in check out and tuneup.

Checkout

With the printed-circuit board interconnected with the external controls, plug in the 110 volt line and turn power on. Check the output of U6 first. You should see 18-volts DC. If you don't, stop and determine why before continuing.

Now that you have a working power supply you can check out and set up the tuner. For that you will have had to measure its operating voltages while it is still in the old TV receiver, or have the Sam's Photofact for that receiver on hand. You will also need a working TV receiver in order to pretune the tuner. Continue with your reading, those matters are fully discussed ahead.

If your tuner's B + voltage was significantly lower than 18 volts as measured when in the original TV receiver, or indicated by the Sams publication, you will have to drop the voltage to it with a series resistor. That series resistor is in the line interconnecting terminal C on the circuit board and the B + voltage terminal on the tuner. Refer to Fig. 1. Use a decade box or a variable resistor to set the series-resistance level. If a series resistor is required, be sure to place a 10-µF filter capacitor from the tuner side of the resistor to ground.

If the tuner you are using was removed from a color television it may have an input for automatic-frequency control (AFC). That input is fed by a discriminator circuit which constantly checks the frequency of the incoming IF signal. If the signal's frequency is not correct, the circuit produces an error voltage that shifts the frequency of the tuner's local oscillator. The shift is in a direction that automatically brings the IF signal back to the correct frequency.

Since the TV Sound Receiver does not require that circuit, you will have to set a DC voltage at that input with a resistive voltage divider. A 10,000-ohm variable resistor can be connected from the B + supply to ground with the wiper going to the AFC input. The resistor is then adjusted to provide the necessary voltage level that appeared at that terminal when it

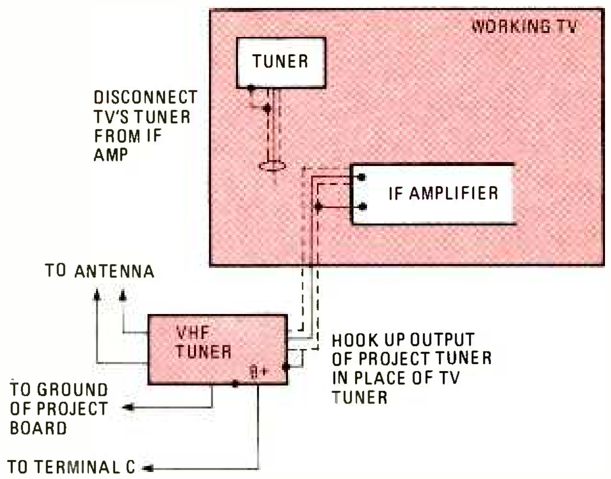


FIG. 5—THE TUNEUP PROCEDURE requires the use of a know-good TV receiver to accept the IF signal from the TV Sound Receiver. The text cautions the experimenter on hazards due to *hot* or *floating* ground conditions in modern TV receivers. Use extreme caution during this procedure and follow the text instructions carefully—take no chances!

was taken from the original receiver. Once the level is set, the variable resistor can replaced with fixed resistors.

The same procedure must be followed for the AGC input to the tuner. The AGC voltage should be set during the pretuning process—to be described next.

Tuneup

Open up a working TV receiver (not the one that was scrounged for the tuner) and connect the IF output of the project's tuner to the IF input of the TV receiver. Power-up both the TV and the TV Sound Receiver (see Fig. 5). Be careful here—the chassis may be connected to the AC outlet and be *killer* hot! Connect the project to a good TV antenna. Set the tuner to a strong local station and adjust it for a normal picture and sound on the TV.

Adjust the project tuner's AGC until there is snow in the picture. Now back off the adjustment until the snow just disappears. That completes the pretuning process; do not change the setting of the tuner controls until all of the remaining adjustments are complete.

Disconnect the tuner's IF output from the TV and hook it up to the IF input of the project board. You are now ready to tune the project's video IF amplifier. There are two methods of doing that. The first, and by far the easiest method, is with the use of an oscilloscope.

Connect the scope probe to the output of (pin 4) of U2. See

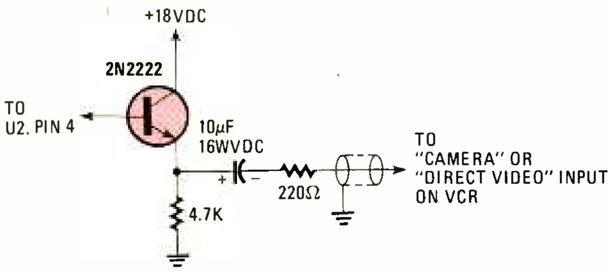


FIG. 7—ONLY FOUR PARTS are needed to interface the TV Sound Receiver with a video tape recorder for the tuneup procedure. Thus, you can use the modulator in the recorder to transmit the TV signal. See text for details.

Fig. 1. With either end of R16 temporarily lifted from the printed-circuit board (an open circuit) preset R19 for 8.8 to 9.0 volts at its wiper. Now adjust C3 and C6 simultaneously until you see a video waveform on the scope. Continue adjusting the two capacitors until you have the best video waveform you can obtain.

Adjust R19 for 8.6 volts at the wiper then re-attach R16. Check the soldered connection. That will engage the AGC loop.

Now adjust C12 until you get sound. Set C12 where it produces the cleanest signal. Tuneup is now complete. You should be able to switch from one channel to the next and obtain good sound on all.

If you do not have an oscilloscope, there are two alternative tuneup methods.

For the first method, you will have to obtain a RF video modulator, available from Radio Shack (277-221) and with it construct the alignment circuit shown in Fig. 6.

Temporarily connect the output of U2 (pin 4) to the input of the alignment circuit. Connect the RF output of the modulator to the antenna terminals of a working TV receiver. Tune the TV to channel 3 or 4, whichever is not occupied by a local station, and set the modulator accordingly.

As before, temporarily lift one end of R16 and preset R19 for 8.8 to 9.0 volts. You can now adjust C3 and C6 and

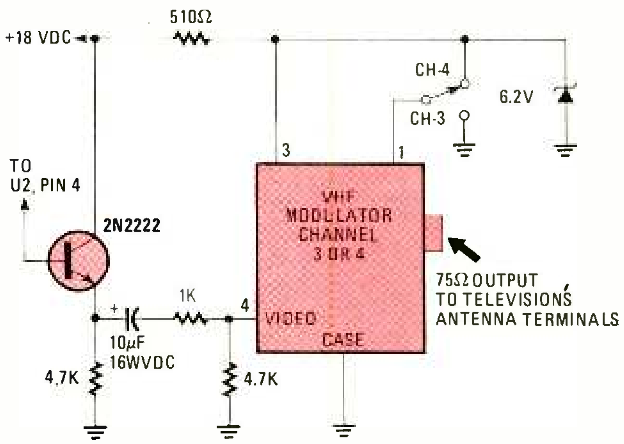


FIG. 6—SHOULD YOU NOT OWN an oscilloscope, the tuneup procedure suggests an alternative procedure using the components wired in the schematic diagram.

observe the result on your television screen. Adjust those two capacitors for the best video that you can obtain.

Do not expect the picture to be perfect, it will have a considerable amount of herringbone and other interference patterns in it due to the lack of the appropriate traps in the TV Sound Receiver.

When you have obtained the best picture possible, tune C12 for the best sound possible from the TV Sound Receiver.

If you own a video cassette recorder, the third method allows you to perform tuneup with no additional purchases. The procedure is identical to that used with the modulator. You must still construct an interface circuit (see Fig. 7); that consists of only one transistor, two resistors, and a capacitor.

The output of the interface circuit is connected to the camera or direct video input of the VCR. You can now use the modulator contained within the VCR to perform alignment. Just tune your TV to whatever channel your VCR is set up to operate on and proceed as already described. **SP**

100-MHz SCOPE PROBE

D.E. PATRICK

The fastest and simplest scope probe ever presented in an experimenter publication

- ***Usable from DC to 100 MHz minimum with gain of 10***
- ***Adjustable gain from less than 1 to over 100***
- ***50-MHz bandwidth with gain over 100 with LH0033 buffer***
- ***Usable bandwidth to 200 MHz with LH0063 buffer***
- ***Slews at 1500 μs (6000V/μs) using LH0033 (LH0063)***

☐WHERE THE USE OF HIGH-IMPEDANCE INPUT, LOW CAPACITANCE, and passive, divider oscilloscope probes is standard practice, higher impedances and lower shunt capacitances will translate into trade-offs such as less gain. We can see that in Fig. 1. In Fig. 1A, the oscilloscope's input impedance may be represented by a resistance in paralleled with a capacitance, with typical values of

R_s = 1 Megohm, and
C_s = 20 pF.

In Fig. 1B, a divider probe is placed in series with the oscilloscope's input, with the probe having typical values of

R_p = 9 Megohms,
and C_p = 10 pF.

And in Fig. 1C, the oscilloscope-probe combination is simplified to

R_{in} = 10 Megohms, and
C_{in} = 7 pF (approximately).

As R_p increase and C_p decreases (Fig. 1B), R_{in} and C_{in} (Fig. 1C) increase and decrease, respectively, along with proportional decreases in oscilloscope gain.

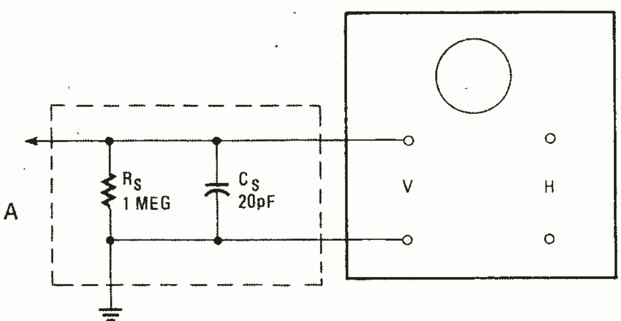
However, even 10-Megohm impedance is often insufficient when trouble shooting some FET, MOS, and CMOS circuits, where, to ensure resistive loading errors of less than 1%, the oscilloscope-probe impedance combination should be on the order of 100 times greater than the circuit under text (CUT). When R_{in} approaches the impedance of the CUT, significant errors will result due to loading which can both alter performance, or stop that circuit from working altogether. The percentage of error is given by mathematical expression:

$$100Z_{cut}/(Z_{cut} + Z_{in})$$

where Z_{in} is the parallel combination of R_{in} and the impedance of C_{in}.

Now, consider the effects of C_{in} as a function of frequency. In Fig. 1C, C_{in} has an impedance of approximately 23 Megohms at 1 kHz; but at 1 MHz its impedance drops to 23,000 ohms; and at 100 MHz the combined oscilloscope-probe load appears to many circuits as short circuit.

Also, consider the effects of Fig. 1C on rise-time measurements. In Fig. 2A, we have a signal generator with a 400-ohm internal resistance with an internal shunt capacitance of 20 pF. The signal generator's output rise time, R_t, is approximately equal to $2.2(R_gC_s)$, or 17.6 nanoseconds (ns)—as-



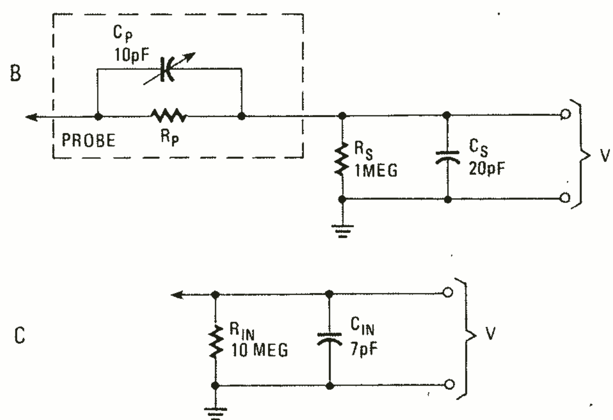
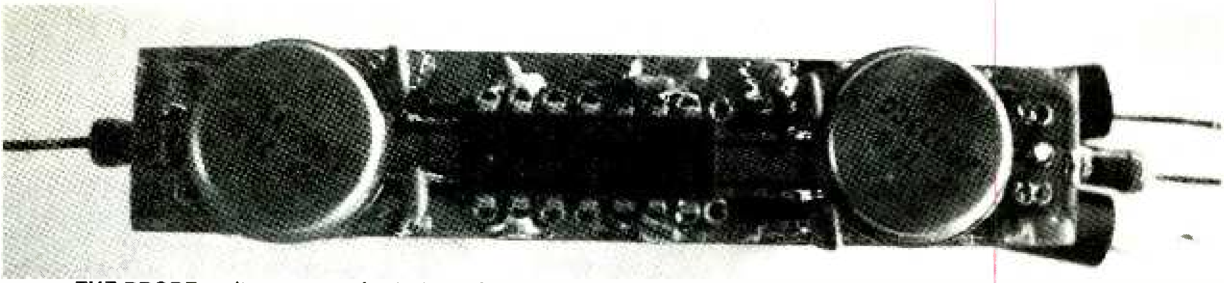


FIG. 1—FOLLOW THE TEXT discussion on the capacitive loading effect on an oscilloscope and discover how probe and circuit capacitance can effectively reduce the gain of the oscilloscope beyond its practical use at high frequencies.



THE PROBE as it appears prior to insertion into the tubular casing. The input end is at the left. The IC's are shown in numerical order from left to right. The home-brew, printed-circuit board has foil surfaces top and bottom.

suming R_t started with a signal which had zero rise time. The equivalent circuit with the probe taken into account reduces to that in Fig 2B. We can ignore R_p since it's so much higher than R_s, but C_g and C_p are additive. So,

$$R_t = 2.2\,R_g(C_g + C_p) = 26.4\text{ ns},$$

which represents a significant error, ignoring any errors which will be introduced by the oscilloscope itself.

Obviously, while a passive divider probe has its place, it also has its drawbacks. However, some of those drawbacks can be minimized by active probes, which provide higher input impedances, lower shunt capacitance, and even gain for low-level signals instead of gain trade-off.

Going Further

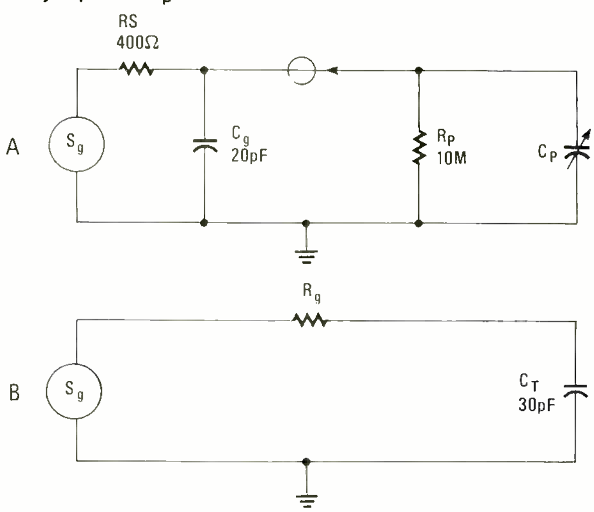
One of the easiest ways to get high-input impedance and low-input capacitance without unwanted gain trade-off is simply to use a "fast" LH0033, "damn fast" LH0063, or equivalent buffers. See Figs. 3 and 4. Those devices offer input impedances in the 10^{11}-ohms range shunted by 2 pF with slew rates of 1500 V/µs and 6000 V/µs respectively, and will operate at frequencies in excess of 100 MHz. The LH0033 will push ±100 mA of continuous current maximum into a load with ±200-mA peak maximum, and propagation delays in the 1.2-ns range. On the other hand, the LH0063 will push ±250 mA of continuous current into a load with ±500-mA peak maximum.

Both devices can be operated off single or dual power supplies up to 40 volts, can be short-circuit protected, and can have input protection diodes added. When the diodes (D1 and D2) are connected to ground, the signal is protected at he limits of ±0.6 volts (one diode voltage drop above and below ground). Connecting the diodes to higher voltages (positive for D1 and negative to D2) extends the limits to one diode voltage drop above and below those levels. Those voltages are $+V_L$ and $-V_L$ in Figs. 3, 4, and 5.

The less expensive LH0033 will typically drive 200-pF loads including coaxial cables and over 1000-pF loads at reduced slew rates. Also, damping resistors (see Figs. 3 and

(Continued on page 36)

FIG. 2—THE SIGNAL SOURCE (S_g) presents a load to the probe. We must consider the total load on the oscilloscope. Resistances shown here are not critical, however, C_g and C_p are summed for a total loading of C_T. R_g is effectively equal to R_p in this instance.



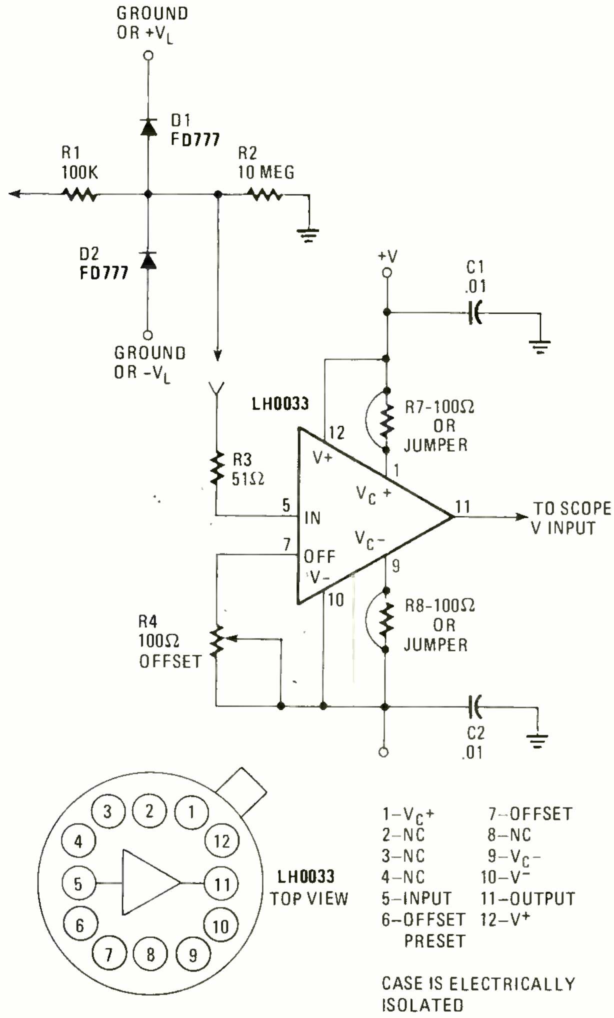


FIG. 3—CAPACITIVE LOADS at the input of the 100-MHz probe can be handled by the LH0033 for values up to 200 pF and up to 1000 pF at reduces slews. Always consider the coaxial cable capacitanced added to the circuits capacitive load. Resistors R7 and R8 are added for capacitive loads above 1000 pF to limit excessive output current.

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WE GIVE YOU TOMORROW.

100-MHZ SCOPE PROBE

(Continued from page 32)

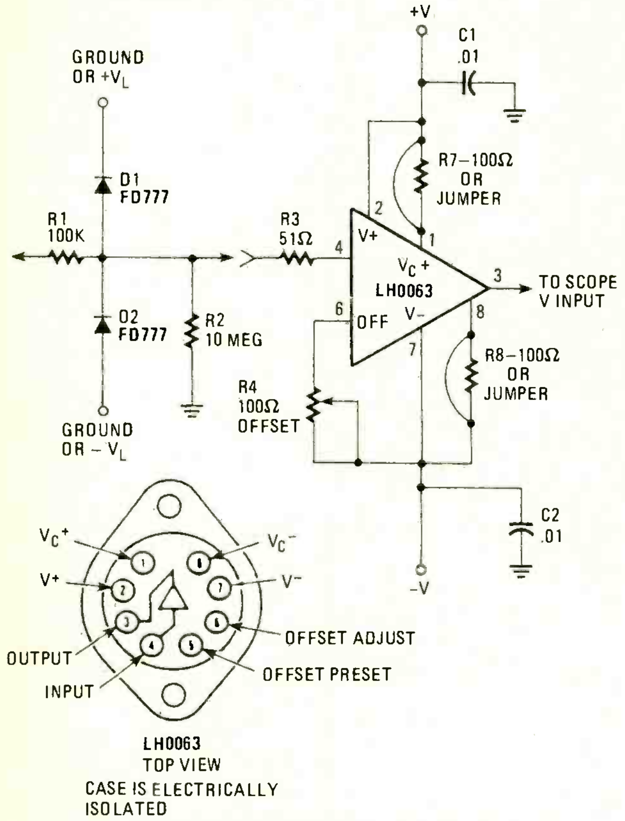


FIG. 4—TWO ADDITIONAL OPTIONS available to the project builder at the signal-input end of the 100-MHz probe. Those options costs should be checked against performance gains as described in text.

4) can be added at pins 1 and 9 when driving large capacitive loads, where C_{LOAD} is greater than 1000 pF. Optional resistors R7 and R8 will also limit excessive current output.

Putting it All Together

The circuit for the 100-Mhx Scope Probe shown in Fig. 5 has all the advantages of a fast buffer input, adjustable gain and an optional cable-driving, buffer output.

Optional input protection for U1 can be added by R1, D1, and D2 with R2 setting the input impedance if desired, with some sacrifice in input shunt capacitance. However, I opted to use no input protection allowing input shunt capacitance to be at least 2-pF spec'ed for the LH0033, which actually turned out to be a conservative specification. The input capacitance for the LH0033 without the protection circuit for my unit was actually under 1 pF. *(Continued on page 97)*

PARTS LIST FOR 100-MHZ SCOPE PROBE

SEMICONDUCTORS

D1, D2—FD777 signal diode (optional)

U1, U3—LH0033 wide-bandwidth, buffer/voltage-follower

U3 is an optional line driver)

U2—NE592 video amplifier with variable gain

RESISTORS

(All fixed resistors are 5%, film, 1/4-watt unless otherwise noted)

R1—100,000-ohm

R2—10-Megohm (optional)

R3—51-ohm

R4-R9—500-ohm, miniature potentiometer

R5—50,000-ohm, miniature potentiometer

R6—43-ohm (Build-out resistor for 50-ohm coax)

R7-R8—100-ohm (optional--see Fig. 4)

R10—47-ohm

R11, R12—2,200-ohm

R13—100-ohm

ADDITIONAL PARTS AND MATERIALS

C1-C6—.01-µF monolithic, or low-inductance capacitor

C7, C8—10-µF, 10-WVDC tantalum capacitor

FB1, FB2—Ferrite bead (ETC 223-453)

Printed-circuit material, probe tip, light-weight shielded cable, probe housing (see text), wire, solder, solder braid, etc.

A complete set of parts is available from E.T.C., P.O. Box 29278, Denver, CO 80229 for $100.00 prepaid.

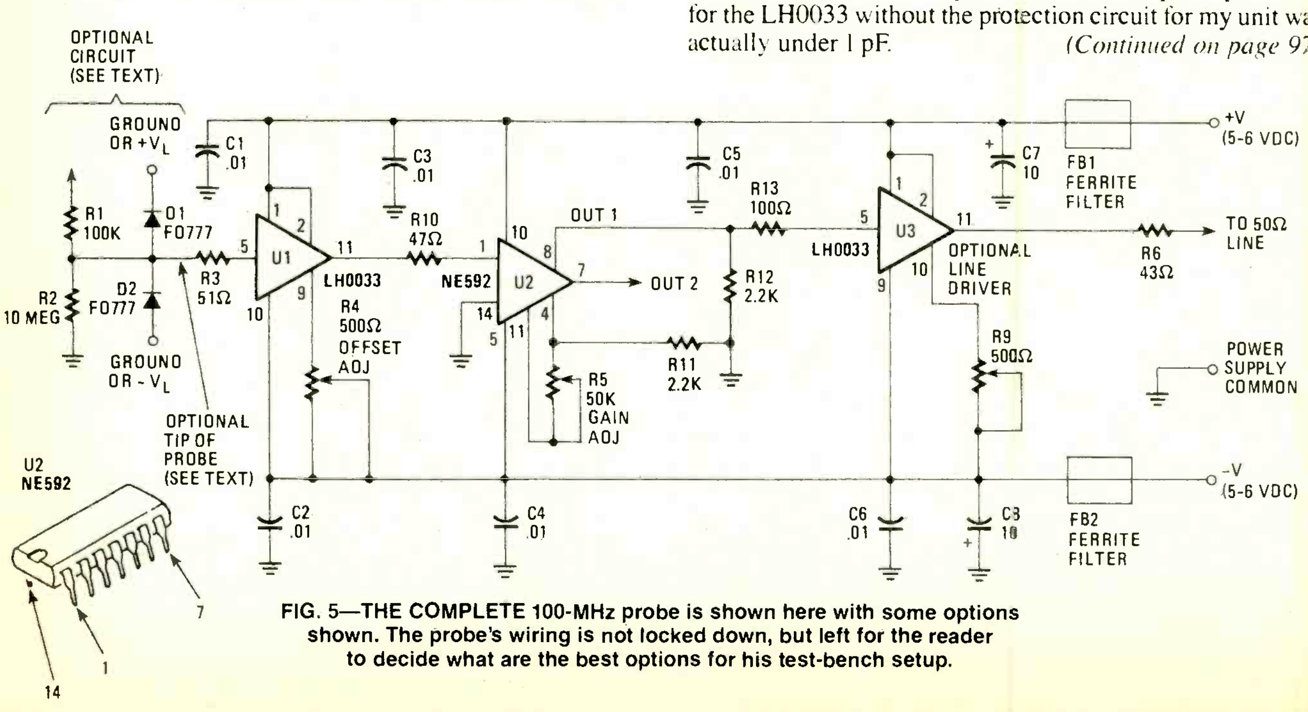
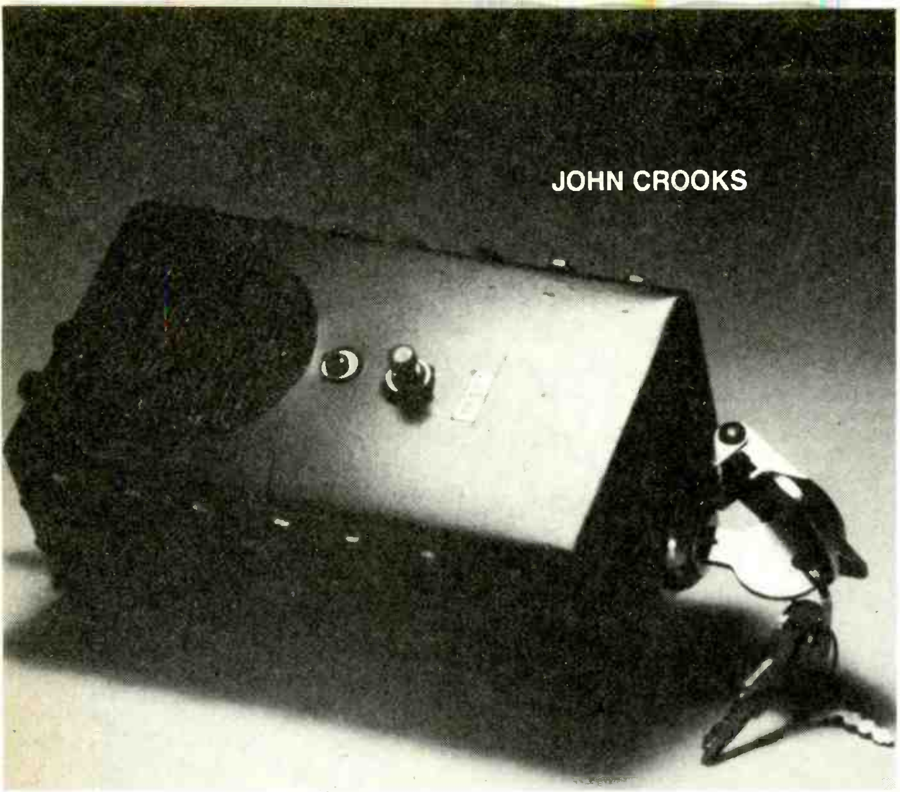


FIG. 5—THE COMPLETE 100-MHz probe is shown here with some options shown. The probe's wiring is not locked down, but left for the reader to decide what are the best options for his test-bench setup.

JOHN CROOKS



THEFT ALARM

More valuable than a travel clock, this totable burglar alarm device protects a single item while you are unaware or asleep. Inexpensive to assemble, it adds more insurance to your valuables by eliminating the sneak theft!

☐THE THEFT ALARM IS A SMALL ALARM BOX DESIGNED TO be attached to a single valuable. When that valuable is moved, the Theft Alarm senses the change in attitude and sounds a siren. It is an easy way to protect an individual object from theft without installing a complicated and costly whole-room alarm system.

The Theft Alarm was inspired by today's college atmosphere. College dormitories are not the safest places to have such things as stereos, typewriters, computers, television sets, and bicycles. But they must be kept there!

There are certainly college students who read this magazine and might be interested in the alarm, but the homeowner and small-businessman should also be interested. Hearing of another break-in in the neighborhood is not the most comforting, nor the most uncommon bit of news. And corporate theft is on the uprise, though a small-business owner would probably already have a conventional burglar-alarm system. But that extra bit of protection attached to the new computer or cash drawer might be just what it takes to get a good night's sleep.

There are some special features to the Theft Alarm that make it especially convenient and well-suited for dormitory and other communal life. To foil the intelligent thief having enough foresight to try to disarm the device, a key switch has been incorporated to turn it on and off and a tamper-proof enclosure constructed. To avoid bothering neighbors, an arm-on and siren-on delay are included to allow the user time to arm and disarm the circuit without the siren sounding accidentally. And when it does go off, the siren resembles a pumping whistle more than a simple horn or buzzer that could be dangerously mistaken for a smoke alarm.

The completed project can be bolted to, chained to, or set on top of, any object. Some have been mentioned previously, but others like file drawers, stacks of important documents, storage drawers, doorknobs, etc., can also be protected from theft or tampering.

The Circuit

Referring to Fig. 1, we can see that the Theft Alarm can be seen as five simple circuit sections: power, arm delay, trigger, siren delay, and siren. Except for the power section, each is designed around some version of the popular 555-timer integrated circuit.

Two batteries supply the power, B2 for the siren and siren delay sections, and B1 For the trigger and arm-delay sections. That dual-battery setup is designed to prolong overall battery life. The trigger battery, B1, has only to power U2 and U3. Those chips are CMOS versions of the 555 timer and require very little power. The siren battery, B2, must power U1 and U4, high-drain linear versions of the 555 timer. B2 works only intermittently and so remains virile. B1 is slowly but constantly drained away, but it can be drained much more than B2 before it must be replaced. In the author's prototype, a heavy-duty battery, too run down to be useful for anything else, lasted a good month as B1. In other testing, alkaline batteries used for B1 and B2 have yet to run down.

System operation progresses as such: Turning the power on with S2 starts the arm-delay circuit, a 7555-timer, U3, which is wired as a one-shot multivibrator. Triggering of U3 is assured by C5 and R11 on pin 2. The delay time can be adjusted by the setting of R12 or, if an interval longer than about eight seconds is desired, the value of C6 can be increased. The output from pin 3 goes to LED1 in the trigger circuit.

The trigger circuit includes another 7555 chip (U2), but this time it is wired as a flip-flop. During arm delay, the high from U3 disables and resets U2 while at the same time lighting LED1.

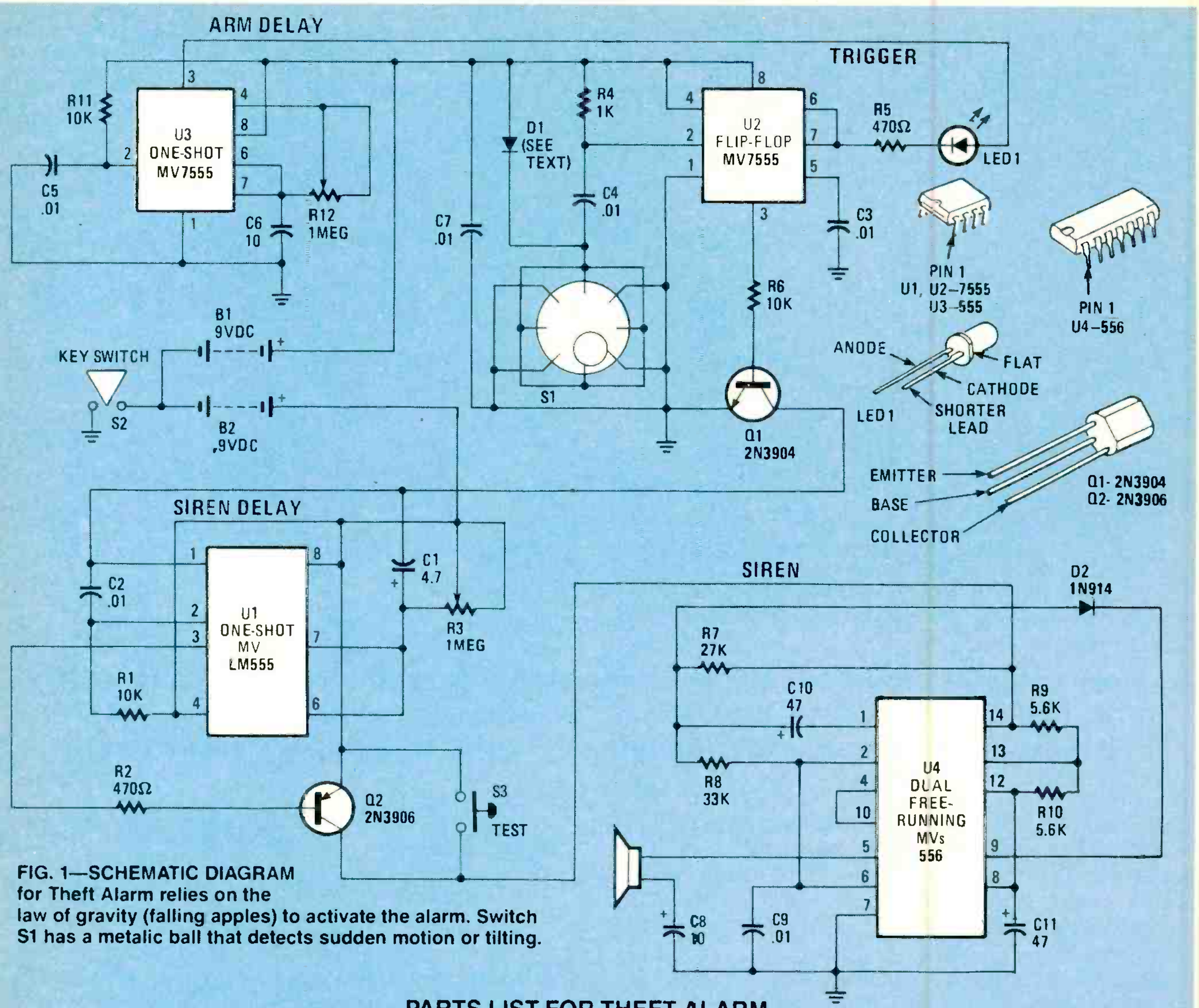


FIG. 1—SCHEMATIC DIAGRAM for Theft Alarm relies on the law of gravity (falling apples) to activate the alarm. Switch S1 has a metalic ball that detects sudden motion or tilting.

PARTS LIST FOR THEFT ALARM

SEMICONDUCTOR

D1—signal diode with some measurable leakage (see text)
D2—1N914 diode
LED1—Light-emitting diode
Q1—2N3904, or equivalent
Q2—2N3906, or equivalent
U1—LM555 timer integrated circuit
U2,U3—7555 timer integrated circuit (Available from Digi-Key (#NT5012-ND, catalog available from Digi-Key Corp., PO Box677, Thief River Falls, MN, 56701) and Radio Shack 276-1743.)
U4—556 dual timer intergrated circuit

CAPACITORS

(All capacitors should have minimum 10-WVDC rating)
C1—4.7µF, electrolytic
C2-C5, C7, C9—.01µF, ceramic disc
C6, C8—10µF, electrolytic
C10, C11—47-µF, electrolytic

RESISTORS

R1, R6, R11—10,000-ohm, 10%
R2—470-ohm, 5%
R3, R12—1-Megohm trimmer, 20%
R4—1000-ohm, 10%
R5—470-ohm, 10%
R7—27,000-ohm, 5%
R8—33,000-ohm, 5%
R9, R10—5600-ohm, 5%

SWITCHES

S1—Ball switch (Order #C4418 from Chaney Electronics, P.O. Box 27038, Denver, CO 80227 or #H28-20 from Meshna Electronics, P.O. 62, E. Lynn, MA 09104. Request catalogs from both companies. Each company has a minimum-order requirement, but other needed parts can be purchased, and each catalog has some interesting surplus to fill out an order.)
S2—SPST key switch, key removes in both switch positions. (Key switch S2 might still be available from Meshna (see above) as surplus, but is available from Radio Shack as part number #49-515 or 49-523.)
S3—SPST normally-open, pushbutton-type

ADDITIONAL PARTS AND MATERIAL

B1, B2—9-VDC transistor battery
SPKR1—8-ohm, 2-in., PM speaker
Aluminum case, printed-circuit or perfboard material, piece of foam, decals, wire, firm screen material, black paint, IC sockets, hardware, solder, etc.

Besides showing that the arm-delay circuit is engaged, LED1 gives an indication of B1's strength. A very dim light means that it is time to replace B1. Although the trigger circuit may still function with no light, operation will be erratic. When U3 goes low and LED1 goes out, the trigger circuit is enabled.

The subsystem of R4, C4, D1, and S1 does the actual triggering. S1 is one of the surplus tilt switches that have recently come on the market, though a simple mercury switch would work with decreased sensitivity. The tilt switch just mentioned is nothing more than a TO-5 transistor case containing a ball bearing that rolls around shorting the two lowest contact pins inside. Since the ball bearing is always shorting two pins, C4 is included to minimize current drain through U2 and R4. The resistor keeps the trigger input of U2 high to prevent false triggering and other errant operation. When S1 opens and then closes, a pulse is sent through C4 that overcomes R4 and sets the trigger input of U2 low for a moment, thus *flipping* pin 3 high.

Diode D1 acts as a very high resistance keeping C4 dissipated. Without it, triggering would not be reliable. In the author's prototype, D1 is a grab-bag diode labelled G1, but almost any signal diode will do if it has some measurable reverse-bias leakage. Something like a 1N914 is too efficient and will not work properly. Should you have trouble getting a leaky diode, parallel the unit with a few megohms, and reduce the resistance in small steps if necessary until the leakage is sufficient to operate the circuit.

Capacitor C7 eliminates any small glitches or signals in B1 that might cause erroneous operation. The jiggling of a slightly loose battery clip can produce some frustratingly strange reactions. The flip-flop's (U2) output goes to Q1 and thus provides ground for the siren-delay circuit.

The siren delay circuit works in much the same way as U3 in the arm delay, but an LM555 (U1) is used for its greater output current and resistance to resetting due to power surges. (The siren circuit tends to disrupt the B2 power supply during operation.) The delay time here is a maximum of about six seconds but can be lengthened by increasing C1's capacitance value. U1's output goes to Q2, which forward biases when pin 3 goes low at the end of the delay cycle. The voltage from B2 is then applied to the siren. Switch S3 is provided to test B2 and the siren without triggering the whole unit.

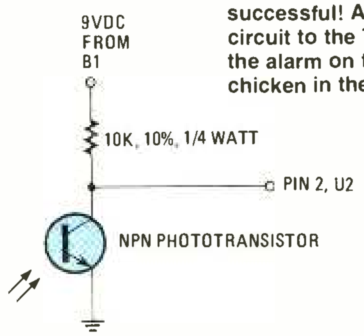


FIG. 2—AN OPTION that will make a diet successful! Add this photo-triggering circuit to the Theft Alarm, and place the alarm on top of the left-over fried chicken in the refrigerator. The interior light, when it comes on will sound the alarm. Pulling the plug will only fool the invader because gravity switch S1 will still be working.

The siren circuit is an LM556 dual-timer, U4, wired as two free-running multivibrators, one oscillating at about three hertz and the other at an audio frequency. The low-frequency output charges C10 on the negative half of its cycle and allows it to discharge through R7 on the positive half. Diode D2 prevents instantaneous discharge while pin 9 is at B2. The frequency of the audio output changes according to the relative charge of C10, creating a distinctive pumping whistle effect. Output from the siren stage goes to SPKR1, a 2-inch PM speaker. Mounted in a metal box, the small speaker can put out a surprisingly large volume of sound.

Resistor tolerances in the siren circuit are listed as five percent in a desperate attempt to keep the frequencies as close as possible to those intended by compensating for the capacitors. Inexpensive electrolytic and disc capacitors are notorious for being way off value, and it only takes a little to make the audio oscillator sound *flat* or the modulation oscillator run too slow. If that ever happens, try putting in different units for C9 and C10 for audio-oscillator problems and C11 for modulating-oscillator problems.

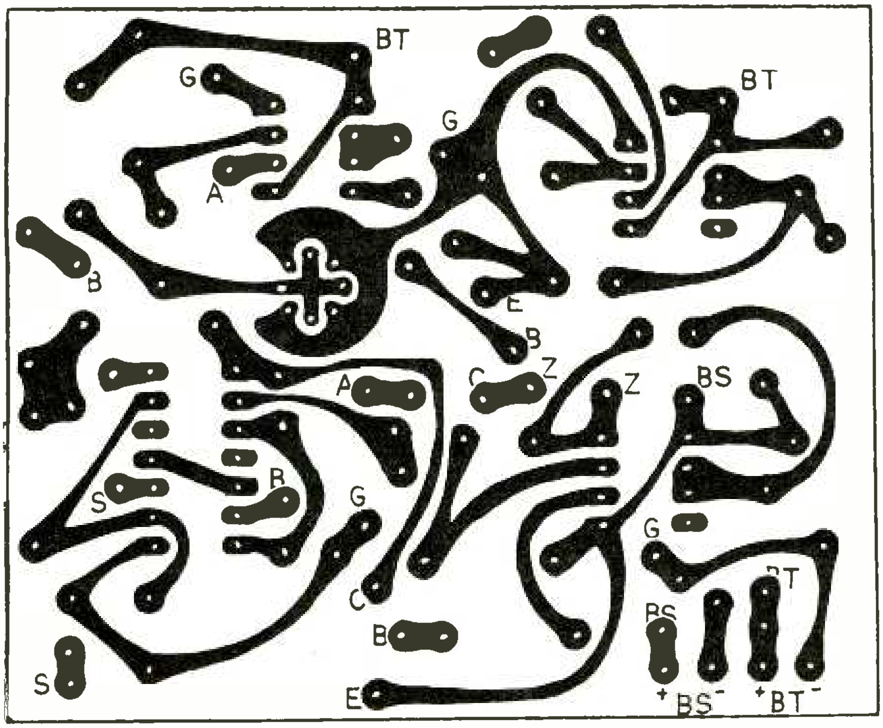


FIG. 3—THE FOIL PATTER shown here is not the one used by the author, since he hand wired the original unit. However, many new comers to hobby electronics will try their hand at this project, this circuit board was developed and tested by the author. Shown same size, the foil pattern is dense and offers sure-fire success for the beginner. The hole locations closely approximate the 0.01-in. hole spacing on perfboards so that you may elect to hard-wire this project. Of course, you may prefer the author's original layout shown in Fig. 5.

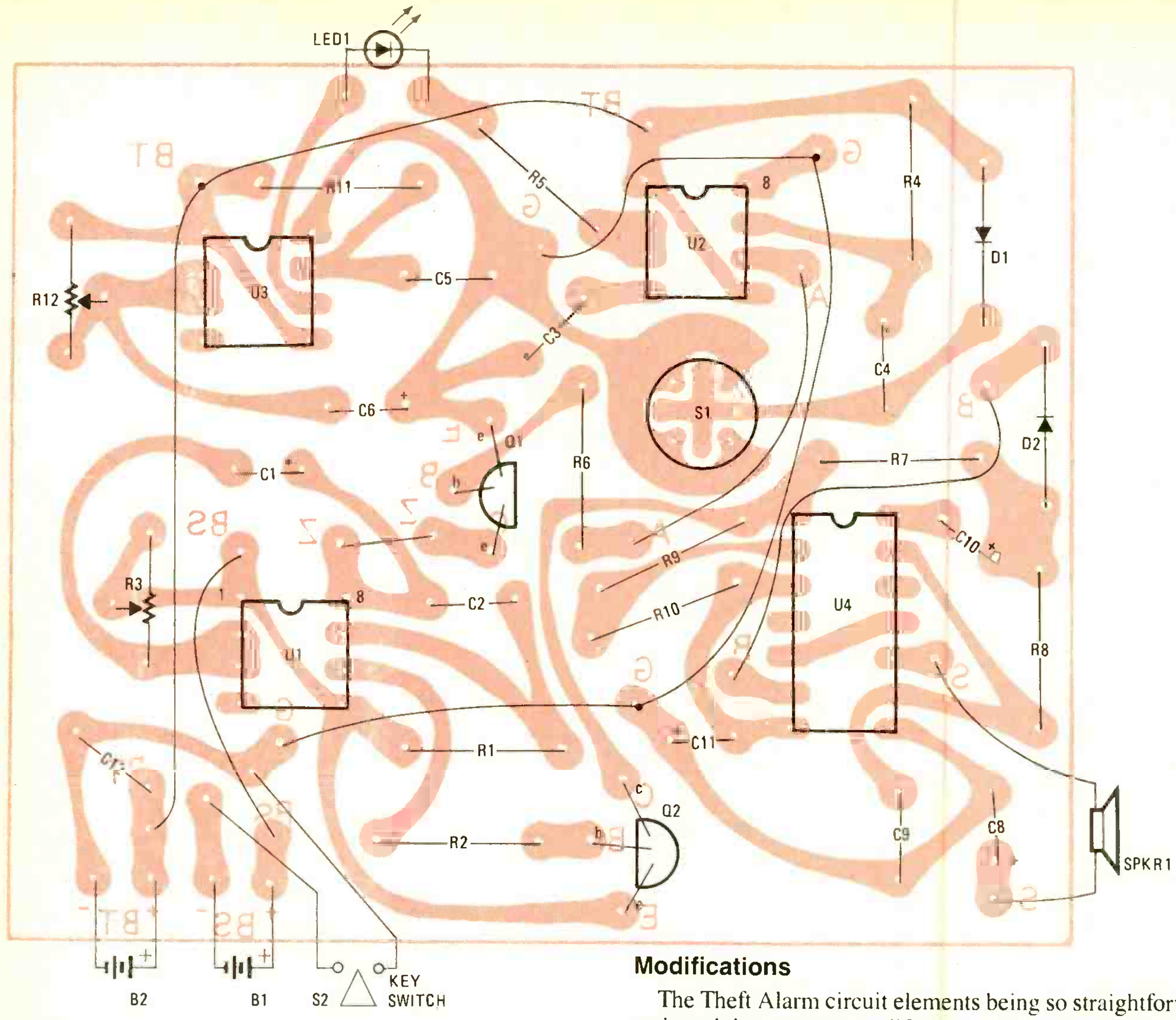


FIG. 4—PARTS LOCATION DIAGRAM and interconnections between the printed-circuit board and the box-mounted parts are illustrated here. Switch S1 must be mounted so that it is level when the board is set in its cabinet. The odd symbol for S1 is the military way of indicating a key-operated on/off switch. In this drawing you are looking down on the surfacing mounted parts and see an X-ray view of the copper foil on the bottom surface.

Modifications

The Theft Alarm circuit elements being so straightforward and modular, custom modifications on the basic circuit are easy. The builder might want to trigger the unit in some other way. Figure 2 shows a subsystem that can be hooked into the trigger section in place of R4, C4, D1, and S1 (see Fig. 1), that can set off the Theft Alarm whenever it senses a transition of dark to light, as in turning on the room lights.

The builder might want the Theft Alarm to operate some house lights instead of the electronic siren already described. A simple power-switching transistor and relay are all that are

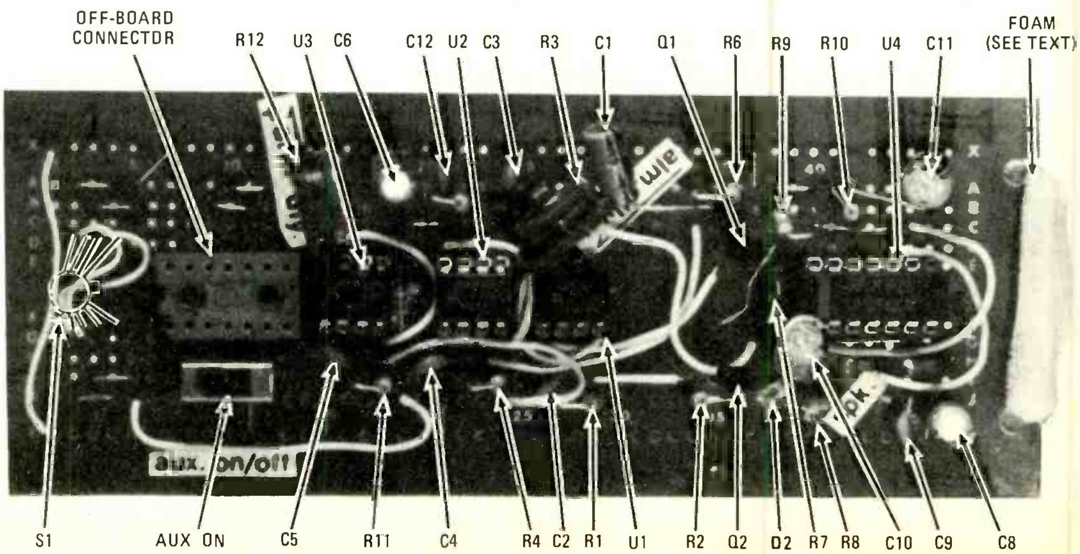
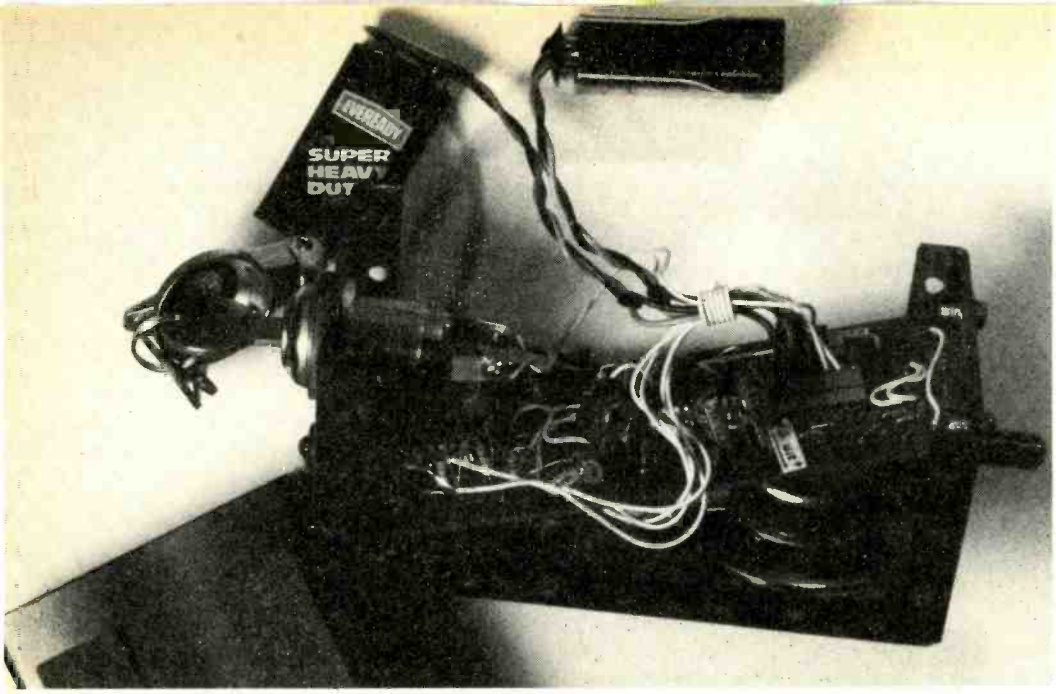


FIG. 5—THE AUTHOR'S original project layout was on a solderless breadboard like Continental Specialties' 300 Experimenter Board. There it was transplanted to the matching predrilled, etched board, and the parts soldered in place. Of course, while on the solderless breadboard, the circuit was tested and made operational under test.



THE THEFT ALARM is all wired up and ready for assembly in its steel box. The catty-cornered circuit board came about because the board was too large for the box used. The author had to wire switch S1 with extended leads so that the switch body could be aligned with the horizontal when mounted in the box. Use a few small pieces of foam cushion material to hold the batteries in the box so that they will not rattle. The author used a large amount of self-tapping screws to seal the box. This would foil an attempt to open the box to disarm the unit when the alarm circuit was in the armed position.

needed in place of R2, Q2, U4, and associated circuitry. B1 and B2 can be made as high as 16 volts to operate a relay directly. Further information on the 555 circuits used here can be found in the LM555 and 7555 data sheets and some of the experimenter books available at Radio Shack and other electronics parts stores.

Construction

The author's prototype was build on a breadboard (Radio Shack #276-170), but any type of construction will do, so long as it is fairly rigid and will withstand some abuse.

The author opted for the breadboard to keep costs down and allow for any alterations that might be needed. For those who want to spend the extra time and money required, a foil pattern and parts-placement diagram are included in Figs. 3 and 4. If they are used, be sure to include the nine required jumpers and be sure that pins 12 and 14 of U4 do not blear together via the trace from pin 13 running between them. The size of the circuit board is compatible with the rest of the construction used by the author.

If the builder decides to use the breadboard, he should use the general layout shown in Fig. 5 to avoid any difficulties with parts getting in the way of other hardware later on. A 14-pin DIP socket is used as an off-board connector (See Figs. 5 and 6) providing easy connection to components on the Alarm's case. The holes on the breadboard correspond with those of many solderless breadboards. The project builder will probably find it easier to stick with the general parts placement only, and work out the placement of jumpers and small parts himself.

For those wishing to use the exact layout pictured, there are several jumpers on the back not shown: (using the matrix numbers on the breadboard) 26X to 11B, 8A to 35H, 10D to 10G, 12H to 20I, and 13J to 17H. Solder bridges connect rows A-E in columns: 13, 14 and 15; 27 and 28; and 22 and 23.

The tilt switch, S1, is attached to the back side at an angle so that it hangs right-side-up despite the tilt of the circuit board (see orientation diagram in Fig. 7). The switch is most sensitive in the vertical position. Wire tails should be carefully soldered to the short leads of the switch, and heat sinks used when those tails are soldered to the circuit board using rows E and F in columns 2-5. Accidental solder bridges are very easy in that area. Descriptions of the switch in catalogs say that a socket is available to fit it. If the builder can find one, it would make things much easier.

The potentiometers must each have one of their outer legs cut off to fit the breadboard matrix. The other resistors are mounted vertically to conserve space. An auxiliary on/off switch was added in the author's prototype across S2 to make testing the disembodied circuit board easier.

Also note that the busses on either edge of the circuit board are used as a common ground for convenience.

Two screw-machined IC sockets were used to connect the board to the box-mounted controls (S2, S3, LED2 and SPKR1). One was soldered to the PC board and the other was used as a DIP header (the tails from one fit into the holes of the other). Wire-wrap gage wire fits nicely into the holes of the one used as a header. For those using the exact layout shown in Fig. 5, a pin-designation diagram is shown in Fig. 6. The battery clips must have scraps of solid wire attached and insulating tubing slipped on to allow them to fit the socket. The speaker in the author's prototype was attached via two slide-on post connectors at 44 and 47-H, but could have been wired through the header with the addition of two jumpers.

IC sockets are strongly recommended, as the pads around those sockets will be repeatedly soldered (if the builder uses the breadboard layout) and the 7555's are relatively expensive. The author used molex sockets. Though CMOS, the 7555's are not static-sensitive— but they are highly heat sensitive.

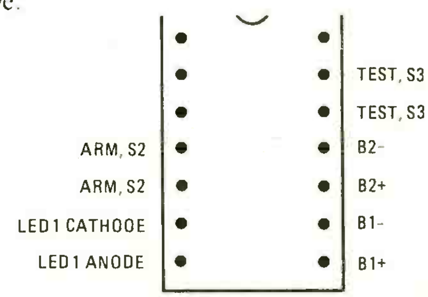


FIG. 6—AN IC SOCKET was used as a connector to interconnect the batteries, test button S3, indicator LED1, and key-operated ARM switch S2. This makes assembly easier.

The enclosure used in the author's prototype was a 5¼ × 3 × 2⅛-inch aluminum box (Radio Shack 270-238). If the builder uses the internal parts-placement diagram shown in Fig. 7, as well as the breadboard, the breadboard will have to be shortened at both ends so that it will fit. A piece of sponge glued to one end of the board stops any rattling and two hex bolts at the other end keep it wedged in with the box open.

LED1 is held in place with a rubber grommet. Two wire-wrap terminal pins were soldered to LED1 and then covered with spaghetti and heat-shrink tubing so that wires could be neatly connected.

The speaker is held in place by a hex screw, much as the PC board is, as well as a speaker mounting bracket from an old radio, though a large washer would have done just as well. Concentric holes were drilled through the aluminum for the speaker. To prevent tampering with the speaker diaphragm, a piece of stiff speaker cloth was epoxied over those holes, blocking access but not sound.

The keyswitch used had a protective cover though it was not required. A rubber washer, like those used inside hose fittings, was put between the outer lock shield and case to prevent the key switch from being unscrewed.

A threaded metal spacer with a hole drilled in the side was bolted to one end of the project so that a loop of plastic-covered steel rope, available at a hardware store, could be attached.

The author's aluminum box came unpainted. If that is the builder's case and painting is desired, a primer must be used on the bare aluminum before any pigment is applied, or the paint will peel off at the slightest scratch. The labels seen in the pictures were made by masking off squares of the box and painting with appliance white spray paint. While the paint was still slightly soft, rub-on letters were applied saying TEST below the test button and ON above the key switch. The tackiness of the paint eliminated the need for a clear coating to prevent the letters from coming off. A professional touch was added by putting small green and red dots of modeling paint at the on and off positions of the key switch.

The batteries were mounted inside the back cover (not shown) so that when the front and back came together, the batteries were on either side of the key switch. Spring clips anchored with silicon cement hold the batteries in place. Battery placement is determined by first cementing the clips in and then doing the final positioning by trial and error, with the batteries in place and the cement half dried and still pliable.

Two strips of foam weather-stripping material were applied to the back to stop the whole project from bumping around or scratching anything it might be set on.

Thirteen hex-head screws were put in each side of the box to secure the back. It is very unlikely that a thief will be able to remove all 26 of them without setting off the Theft Alarm first. The screws were painted black with permanent magic marker. Avoid unnecessary work by delaying installation of the screws until final testing has been performed.

Testing and Troubleshooting

With both batteries in place and all potentiometers at the half-way position, turn the key switch to ON. LED1 should light. After a few seconds, it should turn off. Shake the entire project. After a few seconds, the siren should turn on.

If that is not the case, troubleshoot by testing each stage individually. Pin 3 of U3 should go high and then low upon arming the device. After that, disturbing the tilt switch should make pin 3 of U2 go high and stay that way. That should cause pin 3 of U2 go high and stay that way. That should cause pin 3 of U1 to stay low for a time and then go high. The siren should then go on.

Here are some of the problems the author encountered during various phases of testing:

Alarm triggering is erratic: D1 not leaky enough or open.

Alarm refuses to trigger except by shorting pin 2, U2 to ground: Short between pins of S1.

Alarm pulses too slow: C11 at extreme of tolerance.

A click is heard in the speaker when siren should go on but no siren: D2 too low a rating (blown open).

Current consumptions should be approximately as follows: B1, LED1 on--6mA; B1, with LED1 off--130μA; B1, alarm triggered--850μA; B2, no alarm--no reading; B2, alarm on, speaker disconnected--29mA; B2, alarm on, with speaker connected--fluctuating around 50mA. If that is not the case, look for degenerate components and bad connections.

Try moving the alarm from one place to another without setting it off. It should not be easy. Sensitivity is greatest with the tilt switch, S1, is the upright position, followed by being on its side and then upside down.

The Theft Alarm can be installed using self-tapping screws, bolts, a chain, or a cable. Expanding bolts are best for thin-walled cabinets, boxes, and blow-molded carrying cases. Remember that the Theft Alarm is most sensitive with S1 right-side-up. **SP**

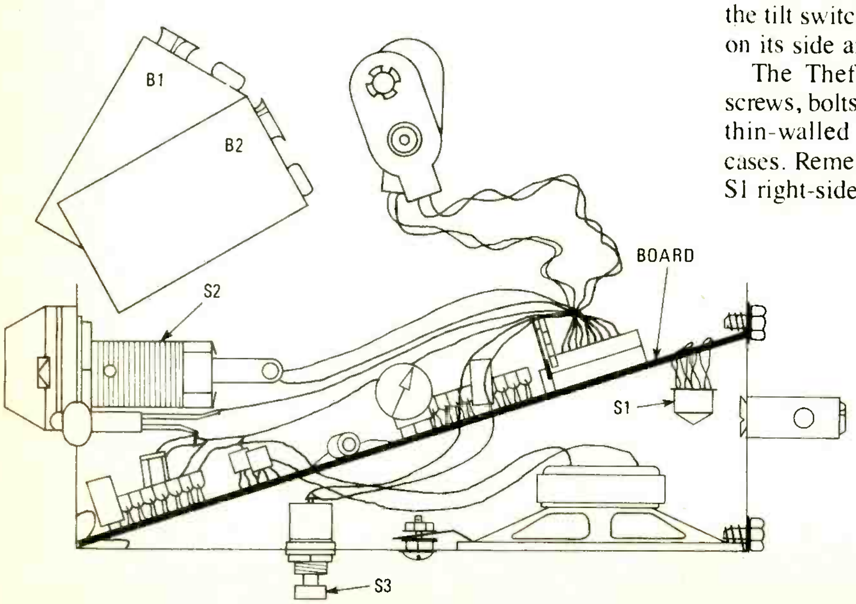
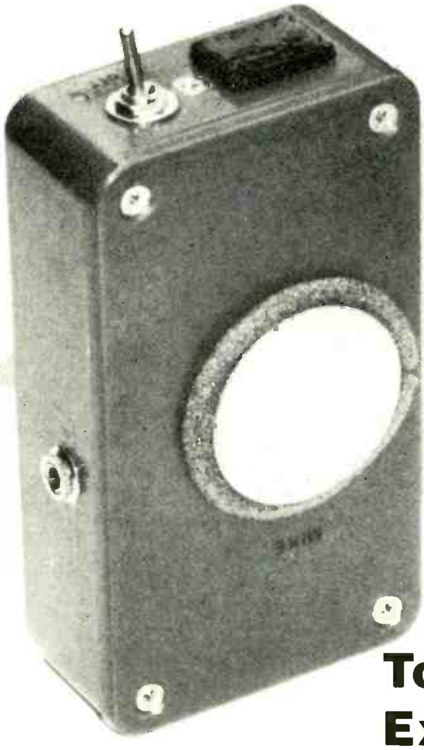
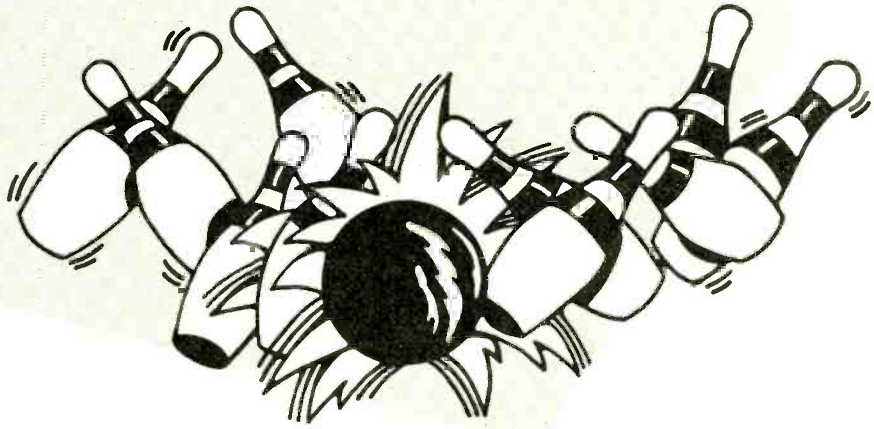


FIG. 7—HERE'S A DRAFTSMAN'S VIEW of the Theft Alarm showing how the circuit board was wedged into the box catty-cornered style. A piece of foam is positioned on the left edge of the board and the assembly pressed gently into position. A hole is drilled and a sBlf-tapping screw inserted above the right edge of the board to hold it in place—a secure, tight fit!

Sound Pressure Monitor





Too much sound will kill your hearing! Exactly how much is too much? Our pocket project gadget tells all!

JOHN CROOKS

☐HAVE YOU EVER USED A POWER TOOL FOR A WHILE, AND then suddenly realized that you've got a splitting headache? Or have you ever come in from mowing the lawn with your gasoline-engine mower and felt as if your ears were under 200-feet of water? If so, then you know how dangerously loud noises can sneak up on you and do unwholesome things to your ears—to say the least. It's called *sound pollution*.

Stop, and listen for a minute. Do you hear a high-pitched ringing, hissing, or roaring that seems to come from nowhere? The chances are that you do. It is known as *tinnitus*, and it is caused by inner ear damage from those long hours with lawn mowers, circular saws, and loud programs on high-fidelity headphones. Children don't generally have tinnitus. But, should you have it, it can get worse—resulting in partial, and even total, deafness.

But there is something you can do to protect your hearing. With the Sound Pressure Monitor described in this article, you can be made aware of high-noise levels. If they can't be avoided, then you will at least know when to limit long-term exposure, or when to wear earplugs.

The Circuit

As you can see in Fig. 1, the simple circuit centers around a common 741 op amp, U1, and LM3915 logarithmic dot/bar display driver, U2.

Crystal microphone MIC1, a high-impedance type, passes its signal through electrolytic capacitor C2 to a biasing network formed by resistors R1 through R4. Capacitor C1 has no apparent function, but the author found that it greatly reduces battery current drain that is so important.

Resistor R5 provides feedback for the op-amp chip, U1. For a value of 340,000 ohms, R5 produces a fairly linear response versus frequency. If a resistor of that value cannot be found, you can substitute 120,000-ohm and 220,000-ohm resistors (5%) in series.

Op-amp U1's output goes directly to centering/calibrating potentiometer R6. Its value is not critical. If a multi-turn trimmer is not on hand, a high-quality single-turn unit can be substituted—thumbwheel-adjustment types do not work well. Potentiometer R6 adjusts the input level to pin 5 of U2, the display driver.

Resistor R7 sets the internal current regulator of U2. Its value will have to be set by the user according to the current demand of the LED display, DIS1, used and the brighiness desired. The amazing thing about the circuit is that the integrated circuits and supporting components only draw about 1.5 mA without the display. The LED display, DS1, itself, can use up to 250 mA more with all segments lighted. If the monitor is run on batteries, the user might want to use the larger value for R7 to reduce battery drain. Typical values for R7 are 470- to 1000-ohms.

Dot/bar-display driver U2's outputs go to a large, single-digit LED display, DIS1, wired to form a circle (rectangle) when a full-scale indication is required. The light-emitting display has an advantage over a row of LED's in that it can be more easily translated into useful information. Instead of counting dots, you simply note the shape of the circle. Not a true circle, the display consists of the six outer segments of

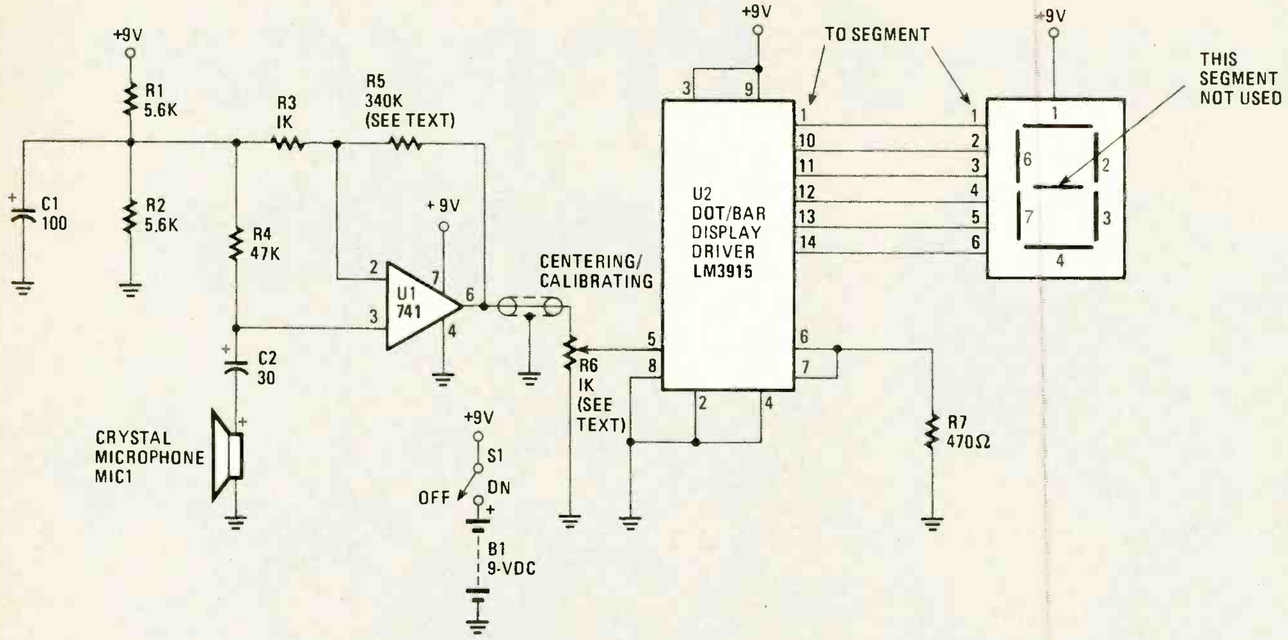


FIG. 1—SCHEMATIC DIAGRAM for the Sound Pressure Meter splits easily into two parts for reader's speedy comprehension. Resistor R5 sets op amp U1 to correct gain for the amplifier stage so that logarithmic LED readout display DIS1 indication is reasonably accurate.

the numeral *8*. The inner segment of DIS1 is not used.

The power source is not critical. A standard 9-volt transistor radio battery can be used. If constant operation is desired, you might want to use an inexpensive plug-in adapter. Just be sure the power jack is the same size as the plug on the adapter.

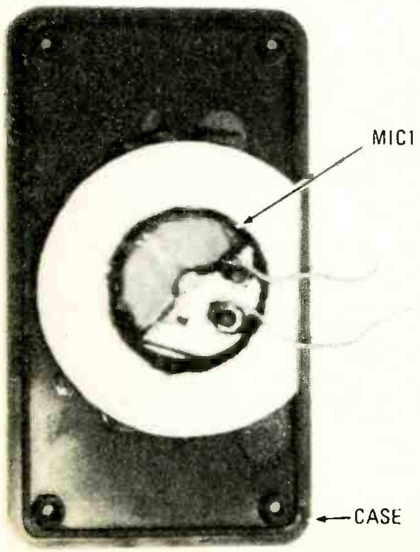
Construction

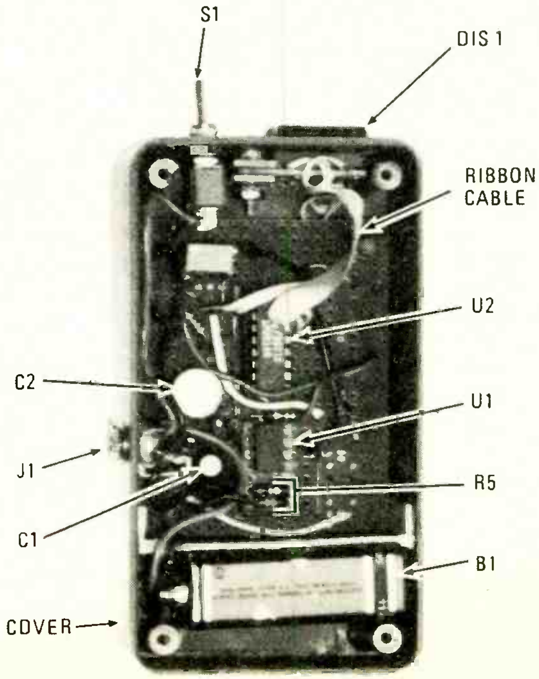
Because the circuit is so simple, it can be built on a perfboard. Better still, use a solderless breadboard and transfer the circuit to a matching printed-circuit experimenter board that duplicates the layout. Since it is not necessary to use the entire board, use a hacksaw to shorten the board to a length that will fit in the plastic case you use. File the cut edge smooth.

You could etch a board for this project, but such a technique is unnecessary and costs more. Another alternative is to wire-wrap, but the result would be a larger volume requiring a larger case, and that is not suitable for portable units.

The use of IC sockets is strongly recommended, since U2 costs about five dollars.

In the actual layout of the Sound Pressure Meter the socket for the eight-pin U1 chip actually has 14-pin positions. The extra holes are used to mount the feedback resistor(s) R5 and to receive the short wires from the microphone that will be mounted on the enclosure's lid. In that way, the entire top cover can be easily removed without any hairy leads to get in





INTERIOR VIEW of the Sound Pressure Meter proves that much can be squeezed into little space when planned properly. Note that MIC1 is secured to the white foam disk with RV cement. Leads from the microphone plug into the unused pinholes in the socket holding U1. Author used J1 to connect unit to power plug/pack. Select a jack that breaks the battery circuit should that option be is used.

PARTS LIST FOR SOUND PRESSURE METER

SEMICONDUCTORS
DIS1—Common-anode, single-digit, LED, readout display
U1—LM741 op-amp integrated circuit
U2—LM3915 Logarithmic LED dot/bar driver integrated circuit

RESISTORS
(All fixed resistors are ¼-watt, 10%)
R1, R2—5600-ohm
R3—1000-ohm
R4—47,000-ohm
R5—340,000-ohm (see text)
R6—1000-ohm, multi-turn potentiometer (see text)
R7—470-ohm (see text)

ADDITIONAL PARTS AND MATERIALS
B1—9-volt transistor radio battery
C1—100-µF, 10-WVDC, electrolytic capacitor
C2—30-µF, 10-WVDC, electrolytic capacitor
MIC1—High-impedance, crystal microphone
S1—SPST toggle or slide switch
Foam weather stripping, battery clip, power jack (optional), case (see text), ribbon cable, IC sockets, perfboard or similar material described in text, wire, solder, hardware, cement, etc.

the way by pulling the wires out of the socket-pin holes.

Even though things may be a bit cramped, use a 4⅜ long × 2½ wide × 1⅛-inch deep ABS plastic box available from Radio Shack to house the Sound Pressure Meter. I found the plastic very easy to work with, and things could be glued in place with plastic model glue.

LED display DIS1 and ON/OFF switch S1 should be put in first to insure enough room for the circuit board and battery.

The display can be mounted to the outside of the case in many ways. One method is to cut a rectangular hole in the case, so that only the pins of DIS1 pass through the shell of the case, touching the sides of the cut hole snugly. Then mount an IC socket onto those pins and squeeze together clamping, DIS1 to the box. A few drops of RV cement will keep the display and socket parts in place thereafter. An *X-acto* hot-knife iron (Unger, among others, makes one for the universal screw-in-heating-element holders) cuts a clean hole in the Radio Shack plastic case. Try to make the hole small at first; then trim it larger until the pins of the display chip just fit through.

If you use a toggle switch to turn on the battery supply, and it has a keyed washer with a locating pin, you can create a locating hole by heating the washer immediately around the pin with the switch in position. Leave your soldering iron in contact with the plate just long enough for the pin to melt its own small hole, not one for the rest of the washer.

Anchor the PC board as close as possible to one end of the plastic box so that ample room is left for the battery. Refer to the photo. Nuts and bolts can be used for that purpose. They should be counter-sunk so that they won't scratch any surface the finished project might be resting on.

In the author's prototype, he used two snap-on stand-offs salvaged from a television set. They were easily glued in with epoxy. The other two corners of the circuit board were stabilized with pieces of sponge glued to the case's floor.

The display can now be connected to the main circuit board via a piece of seven-conductor ribbon cable, as shown in the photo, or lots of hookup wire.

There is not enough room for a standard battery clamp, so use the slots inside the box and some strong cardboard to form a small battery compartment. Everything can be fastened with plastic cement. A piece of foam sponge keeps the battery from moving around.

Microphone MIC1 requires special attention: Not only must it be located where it gets good ambient sound pickup, but it must also not interfere with the other components. With the parts layout given, and the suggested enclosure, those requirements are met with the mike set to one side of the cover.

It would be wise to wrap the microphone with two layers of foam weatherstripping. Not only does that cut down on false readings caused by case vibration, but it covers up any sloppy work done in making the hole. Microphone MIC1 can be fastened by cutting the excess weatherstripping sticking out from the back into tabs and gluing them flat to the inside of the cover with large amounts of plastic cement.

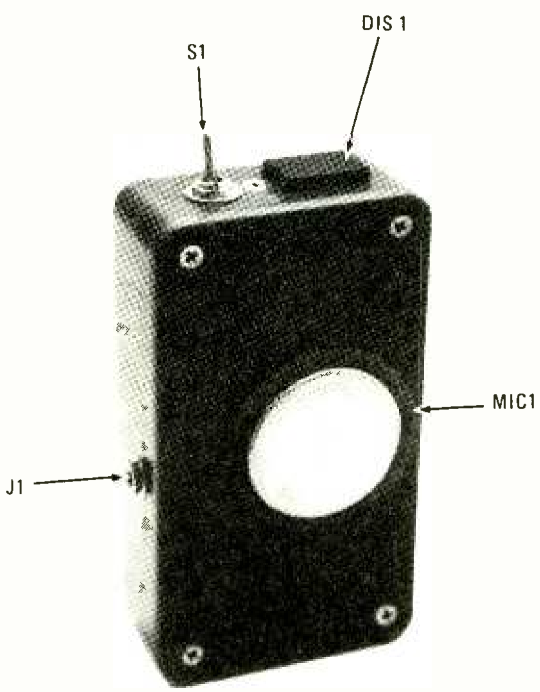
If the adhesive on the weatherstripping does not hold well, and the microphone works itself loose, it can be tacked back in place with spots of epoxy.

Adjustment and Troubleshooting

Before turning the unit on, attach an ammeter to the power supply. You may want to unsolder a wire or two. With all segments of the display on, total current consumption should not be more than about 250 mA. Remember that the IC's only use up about three milliamperes, so the current will be about one sixth lower for each segment not on.

When the switch is thrown, there will be a large current surge due to transcients. The display will come on, turn off for a second, and then come back on. That is normal.

Should the display flicker, insert a 100-µF electrolytic filter



HERE'S WHAT the Sound Pressure Meter looks like after it is assembled and ready for use. LED display is bright enough to be seen in strong light. Bright sunshine may require a cupped hand to make the reading possible.

capacitor in parallel with the power source, B1.

If the current is zero or above 250 mA, something is wrong, probably around the power supply or U2.

Adjust the multi-turn potentiometer, R6, until all segments are lit (if they were not already), and wait a few minutes. Touch U2! If it is abnormally warm, the value of current-setting resistor R7 is too low for the display used. Change it.

Finally, adjust R6 until only the first segment lights. Edge up on the next until it is just about to do the same. Now, tap the face of the microphone with the handle of a small screw-driver. All segments should light for a split second. If the sixth does not, don't worry. Your microphone probably won't respond to signals that great. Variations in op amp U1 could also prevent the last segment from lighting.

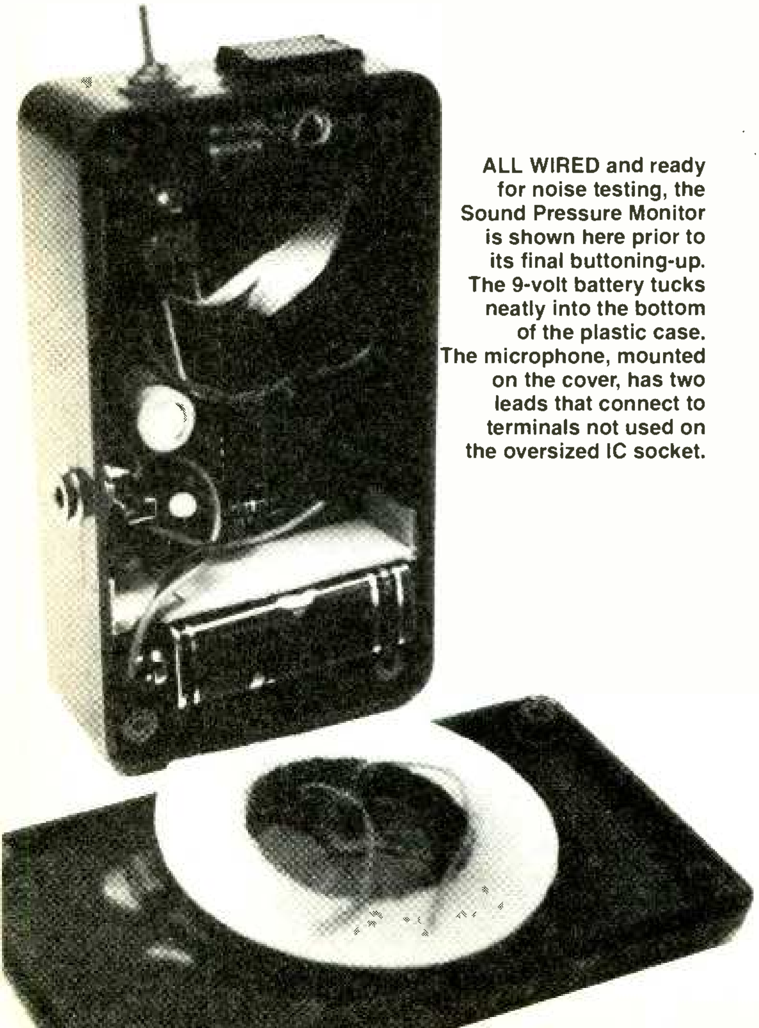
As a final test, bring the monitor within two or three feet of an old-fashioned buzzer-type alarm clock with the alarm on. The second segment should light.

Next, run something extremely loud, such as a car horn or circular saw, in the same room. Five segments should light.

If the monitor fails those tests, one of two things can be done. First, if the unit overreacted to the not-so-loud sounds, R6 can be backed down so that the second segment will not so readily light. If the unit underreacted, you might try changing the feedback resistor(s) slightly or getting another 741 op amp. Chip-to-chip variations, or defects, may be the culprits.

Quirks

The Sound Pressure Monitor has some strange quirks you should know about. To begin with, it is easily led astray by strong air currents on the microphone, such as might be produced by whistling in close proximity. But, just the opposite of what you might expect, the unit is not very sensitive to white noise. Strong vibrations on the surface the Sound Pressure Meter is resting upon can produce false readings, even after the microphone has been isolated with weatherstripping. Extremely high, or low, frequencies produce readings about one step lower than what they should be.


ALL WIRED and ready for noise testing, the Sound Pressure Monitor is shown here prior to its final buttoning-up. The 9-volt battery tucks neatly into the bottom of the plastic case. The microphone, mounted on the cover, has two leads that connect to terminals not used on the oversized IC socket.

DISPLAY INDICATION/MEANING

MONITOR IS ON.

NO IMMEDIATE DANGER FOR SHORT EXPOSURE.

CAUTION—SOME DAMAGE MAY BE TAKING PLACE: EARS SHOULD BE PROTECTED.

MODERATE DANGER—DAMAGE IS TAKING PLACE!

MODERATE DANGER—APPROACHING PAIN THRESHOLD.

IF EARS ARE NOT PROTECTED YOU ARE PROBABLY DEAF BY NOW!

Interpreting the display

The display advances by lighting one LED segment at a time in approximately fifteen-decibel steps, starting at eighty decibels. The first segment of the display to light is the horizontal one at the top. It must be remembered that decibels increase logarithmically. A reading of four logarithmic units is actually 1,111 linear ones.

Interpretation of the display is as follows:

—*one segment* means the monitor is on.

—*two segments* do not mean any immediate danger. Extremely long exposure can cause limited ear damage.

—*three segments* mean caution.

—*four segments* means moderate danger.

—*five segments* is the danger level, approaching the pain threshold.

—*six segments* (if your monitor goes up that high) means that by the time you see that indication, you're probably stone deaf.

Anything above two illuminated segments on DIS1 means potential ear damage.

Remember that most earplugs reduce harmful noise about twenty decibels, the headset types block out even more. Use them to save your hearing.

Also remember that ear damage is more than just a function of how loud the noise is, but how long you expose yourself to it. **SP**

CAESAR'S CLOCK

Had the Romans kept their control of western civilization until now, this would be your clock

HARRY LANDIS

CAESAR'S CLOCK, A DIGITAL ROMAN-NUMERAL DEVICE, consists of two printed-circuit boards and a power transformer enclosed in a wooden case with a smoked-plexiglas front. The smaller of the two printed-circuit boards carries out the logic functions and drives the LED's on the larger, printed-circuit display board. The printed-circuit display board consists of 177 LED's arranged so as to be able to display the hours, minutes, and seconds in their Roman-numeral equivalents.

Principles of Operation

The theory discussion begins with the logic board. Here, 5-volts AC power is obtained from the center tap and one leg of the power transformer (T1) and applied to diodes D1-D4, which function as a full-wave rectifying bridge circuit. Refer to Fig. 1. Capacitor C1 filters the output, which is distributed throughout the printed-circuit board. That output has a nominal value of about 7-volts DC. Zener diode D5 (a 15-volt, 1-watt unit) provides over-voltage protection.

One side of the 5-volt AC from transformer T1 is applied through R1 to the input of one of six Schmitt triggers of U9. (See Fig. 1.) The output of that Schmitt trigger, U9-b, is a 60-Hz squarewave; it is applied to the clock input of a 4024 CMOS seven-stage binary counter (U14). Diodes D6-D9 hold the reset input (pin 2) of the counter low until the counter output reaches binary 60, when resistor R2 drives the reset high and starts the count over. That results in a 1-Hz output at pin 4 of the counter, U14.

The 1-Hz signal is applied, via one of the four exclusive OR gates of U6, to the clock input of U1. (See Fig. 1.) That integrated circuit is a decade counter with 10-decoded outputs which are sequentially driven high by the clock input pulses. Diodes D10 through D26 form a diode matrix, which decodes the outputs of the decade counter to the proper code for actuating all but segment "B" of the Roman-numeral display to indicate 0-9 seconds. The output for segment "B" is obtained by using a Schmitt trigger (U9-c) to invert output 0 for the decade counter. Those outputs are applied to U3 which actually drives the display.

Pin 12 of U1 is the carry-out output which is used to drive U2 at a .1-Hz rate (See Fig. 1.) Output 6 (pin 5) of U2 is connected to the reset input (pin 15) so the counter counts from 0 through 5 and repeats. Diode matrix D27 through D35 the outputs of counter U2 to provide the proper code to drive the seconds display segments for tens of seconds. Segment J of the seconds display is obtained by using an exclusive OR gate (U6-c) to invert the output 0. One of the inputs to the gate is permanently held high so the gate functions as an inverter. Chips U3 and U4 serve as the buffers which actually drive the seconds display.

The counters for the minutes (U5 and U8), with diode matrices D36-D52 and D53-D61 and buffers U7 and U10 behave in a very similar manner to count and display the minutes. Refer to Fig. 1.

To provide the ability to count 12 hours, counters U11 and U12 are interconnected by diodes D62 and D63 and U9-a. (See Fig. 1.) The reset input of U12 is held high until U11 reaches a count of 8 when output, via D62 and U9-a drives it low. On the next clock pulse, U11 advances to decimal count 9 and disables itself while U12 advanced to decimal count 1. On subsequent pulses U12 continues counting until it reaches decimal count 4, which resets U11. As U11 switches to decimal count 0, it resets U12 and the cycle repeats. Diode matrix D64 through D86 and buffer U13 decode the outputs and drive the hours display.

Time setting is accomplished by mercury switches S1 through S3. Resistors R3 and R4 hold the reset inputs of U1 and U2 low until S1 is closed stopping the clock. The closing of S1 forces the reset inputs high and inhibits counting until S1 is opened. Refer to Fig. 1.

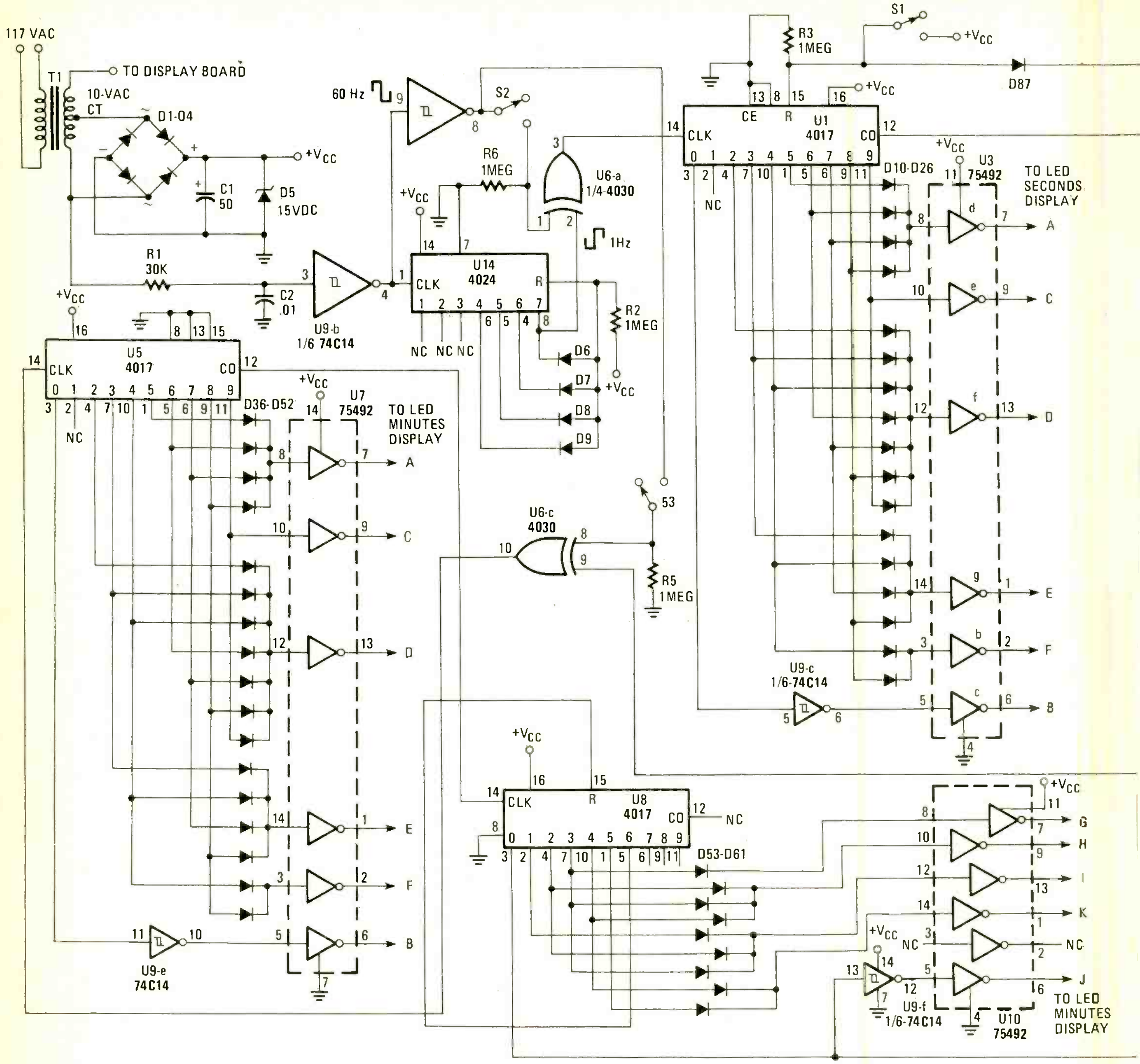
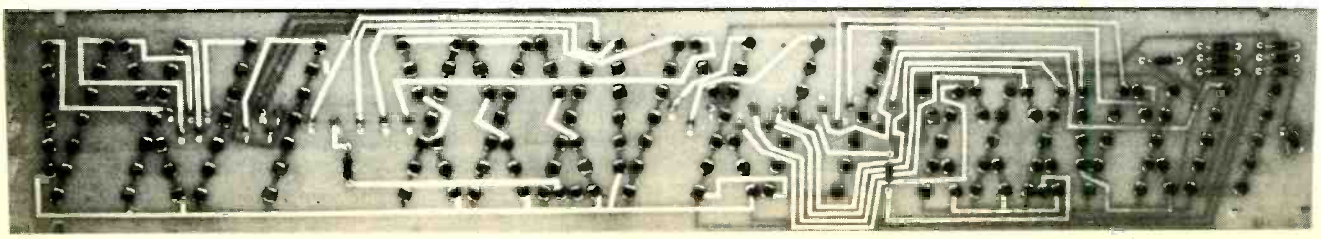
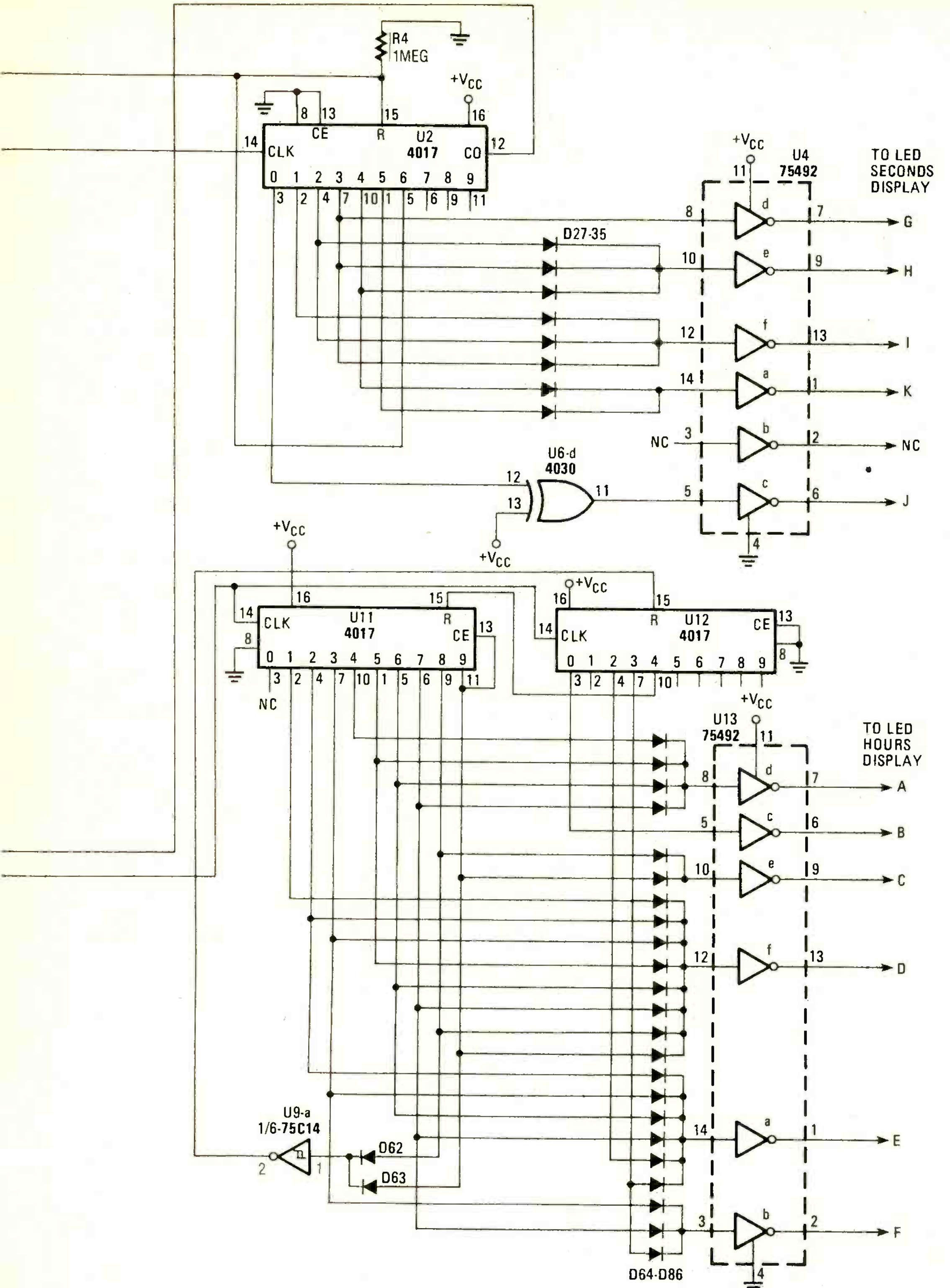


FIG. 1—CAESAR'S CLOCK presents a schematic diagram that looks awesome, but is quite simple once you begin to realize the large number of identical circuits used to drive the light emitting diodes which are shown in Fig. 2.

THE DISPLAY PRINTED-CIRCUIT BOARD shown below mounts all of the display LED's in an array such that Roman numerals indicating the hour, minutes past the hour, and seconds past the minute are displayed from left to right.





The 1-Hz output of U14 is applied to one of the inputs (pin 2, U6-a) of an exclusive OR gate. (See Fig. 1.) The other input (pin 1) is held low by R5. The output is therefore identical to the input and is applied to the clock input of the seconds counter (U1). When S1 is closed, however, pin 1 is connected to a 60-Hz squarewave from U9 and the output is therefore a 60-Hz squarewave. That advances the seconds counter at a 60-Hz rate, and therefore, the minutes counter at a rate of 1 minute-per-second. Switch S3 functions in much the same manner, supplying a 60-Hz signal to the input of the minutes counter, thereby advancing the hours counter at a rate of 1 hour per-second.

LED Display

The LED display consists of 177 light-emitting diodes (LED's) arranged to display hours, minutes, and seconds in Roman-numeral form on the display board. Refer to Fig. 2. Those LED's are connected to form series strings, or segments, of 7, 6, 5 and 4 LED's. Power to drive the LED's is obtained from one leg of power transformer T1 which produces an output of half-wave rectified 10-volts AC relative to the logic printed-circuit board ground. That voltage is slightly too high to drive the 7-LED segments. Thus, it is reduced by a voltage drop caused by two series-connected

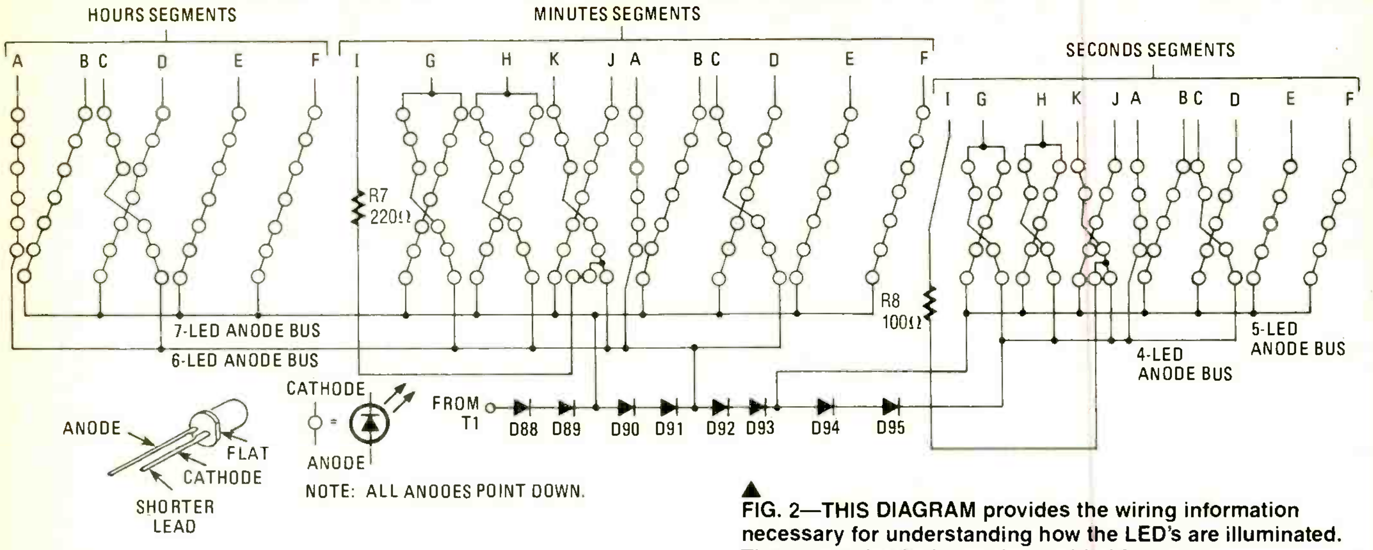


FIG. 2—THIS DIAGRAM provides the wiring information necessary for understanding how the LED's are illuminated. The actual physical array is provided for better understanding of how the Roman numerals are generated.

diodes D88 and D89 and connected to the bus connecting to the anodes of the 7-LED segments.

To drive the 6-LED segments, the 10-volts AC is reduced by another 2-diode voltage drop (D90 and D91) and applied to a bus that connects to the anodes of the 6-LED segments. (See Fig. 2.) In a similar manner, diodes D92 and D93 reduce the voltage for the 5-LED segments, and diodes D93 and D94 reduce the voltage for the 4-LED segments. Segments K of the minutes and seconds displays consists of only two LED's and current through these segments is limited by resistors R6 and R7. When the buffer inputs of the 75492 chips go high (Fig. 1), the open collector inputs go low, allowing current to flow through and illuminate the appropriate LED segments of the Roman numeral display.

Take Notice

Because the CMOS integrated-circuit chips used in Caesar's Clock have extremely high-input impedances, care must be taken to avoid damage due to static electricity during handling and construction. Also, any unwanted conductive paths due to flux residues or contamination must be completely removed by thorough cleaning.

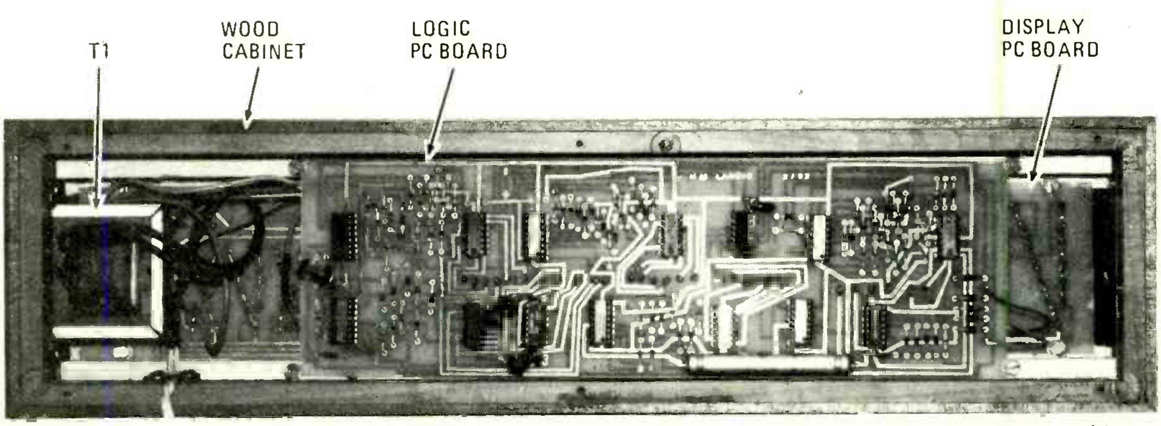
Due to the nonlinear resistance characteristics of the LED's, the waveform of the transformer is affected during that half cycle in which they are on. Therefore, the alternate half cycle should be used to supply input pulses to the Schmitt trigger. That is done by ensuring that the non-center tap leg of T1 is connected to R1. Refer to Fig. 1.

FIG. 3—THE FOIL PATTERNS for the logic PC board are shown same size on the next page. They must be reproduced on the same board, back-to-back, so that solder—through connections interconnect the two foil surfaces. Refer to Fig. 1 to obtain a few solder—through reference points so that the foil surfaces will be aligned correctly.

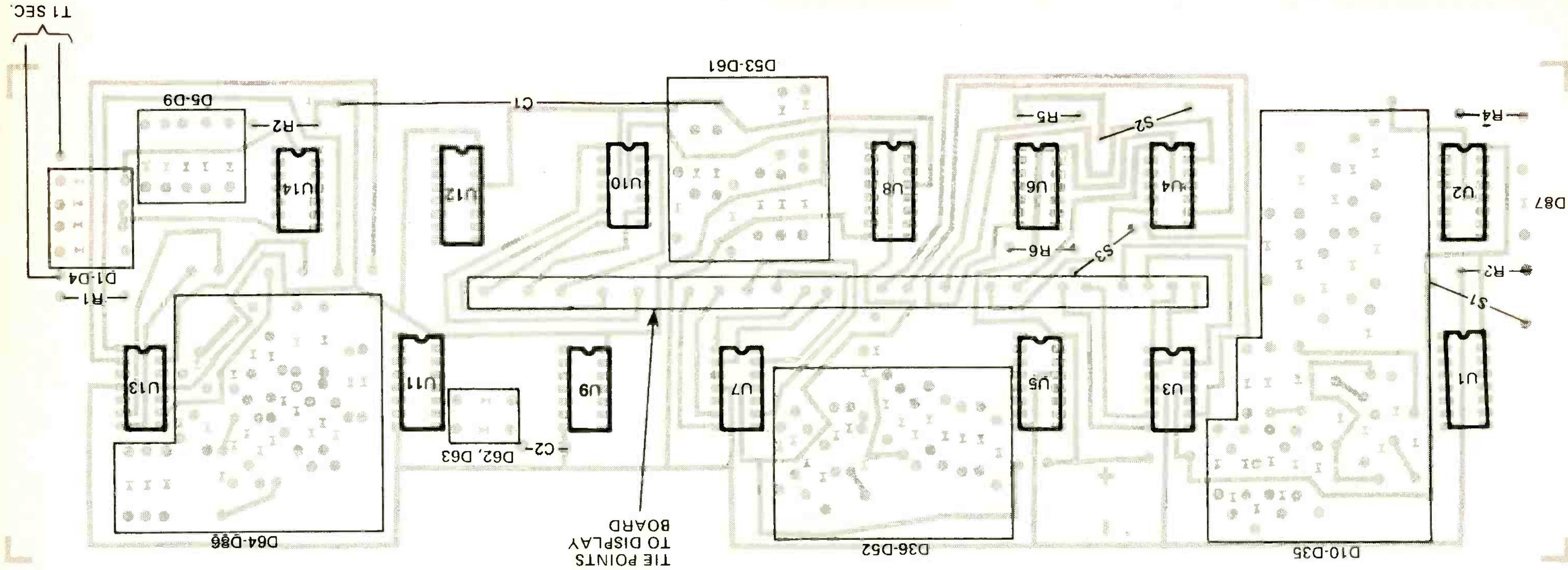
Construction

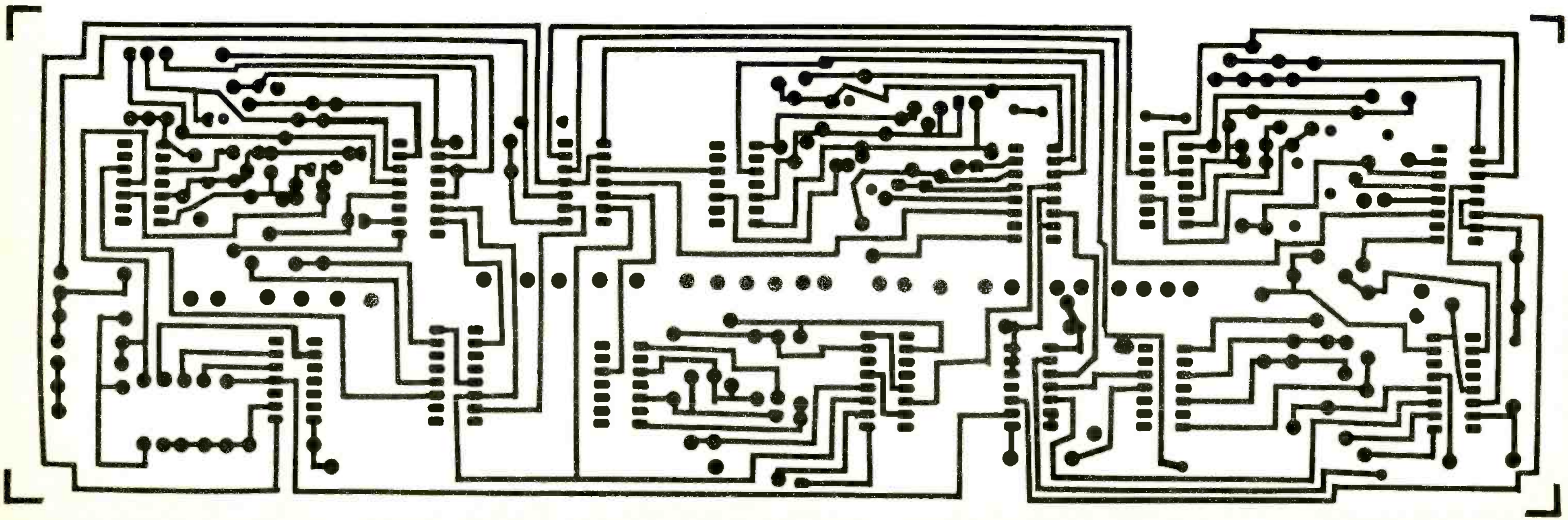
The construction of Caesar's Clock is relatively straightforward. You can either make the two printed-circuit boards (logic and display) or buy them. Refer to the Parts List for details. The drawings of the printed-circuit boards are given in a reduced form so that they would fit on the pages of this magazine. See Figs. 3 and 4. In order to use those drawings, they should be enlarged as instructed in the captions for the figures. Commercially produced printed-circuit boards have plated-through holes to make jumpers unnecessary and to facilitate soldering. If you make your own, you will have to modify the design somewhat by drilling holes to interconnect the traces on the two sides.

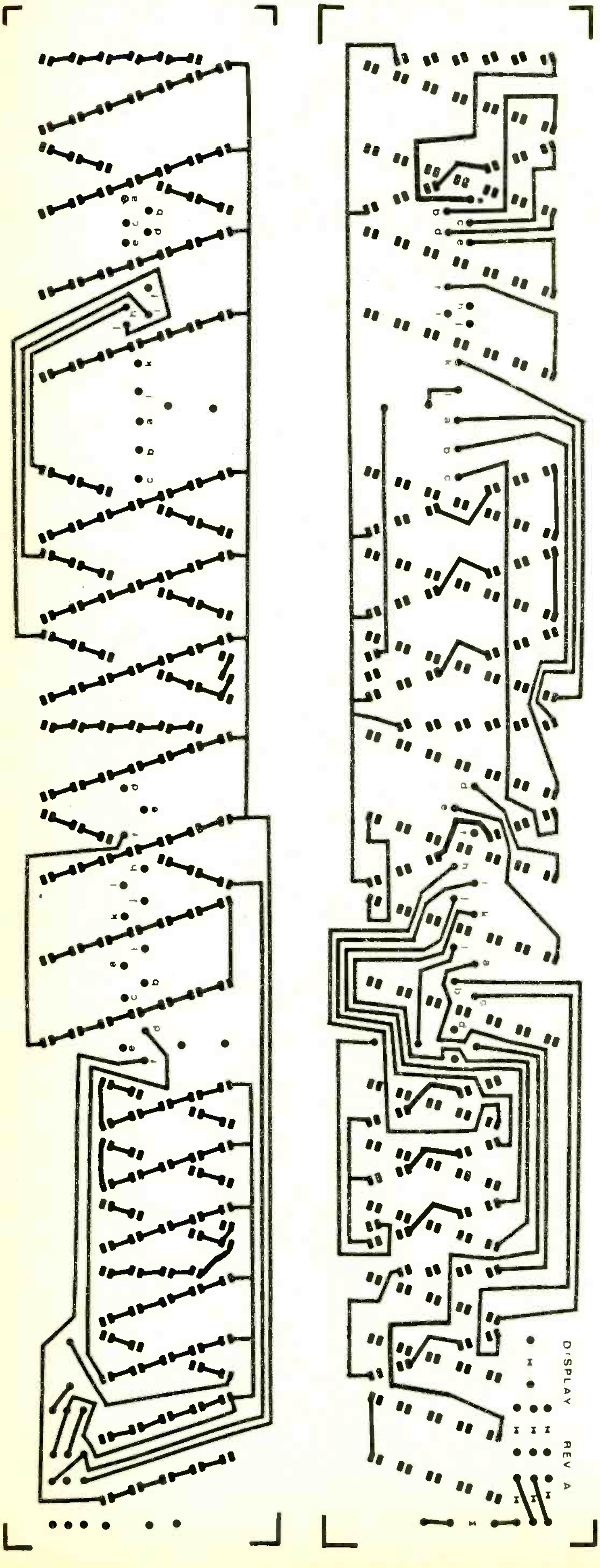
When soldering, be especially careful not to damage the circuit components with excess heat; however, be sure to



HERE'S THE INSIDE VIEW of the Caesar's Clock made by the author. The height and widths of the wood cabinet are determined by the maximum dimensions of the printed-circuit boards. You may want to install the clock in a piece of furniture or wall. Ventilation is not a problem since the clock consumes less than five watts. Mount the logic printed-circuit board so that the components are positioned as shown.


T1 SEC.
D1-D4
R1
D5-D9
R2
U14
U12
U10
U13
U11
U9
U7
U8
U6
U4
U5
U3
U2
U1
C1
C2
D62, D63
D53-D61
D64-D86
TIE POINTS TO DISPLAY BOARD
D36-D52
D10-D35
R5
R6
S2
S3
R4
R3
S1
D87





make a good solder joint. That applies especially to the LED's. Most LED manufacturers set a maximum of only 3 to 5 seconds for the LED's leads to be in contact with the molten solder before damage may occur. Be sure that the pad is clean and well tinned; with a little practice you should be able to master the technique.

The display-board spacing is set to accommodate LED's with lead spacings of .09-in. to .10-in. That is the spacing of all T1 (miniature) and most T1¾ (jumbo) LED's. Some styles of T1¾ LED's have a spacing of only .05-in. and will therefore require their legs to be carefully bent with pliers.

Parts-placement on the display board is obvious when the board is compared to the schematic diagram of the display circuit given in Fig. 2. For that reason, and also to save valuable space in this issue, the information is not supplied in a diagram identifying parts location on the logic printed-circuit board.

PARTS LIST FOR CAESAR'S CLOCK

SEMICONDUCTORS

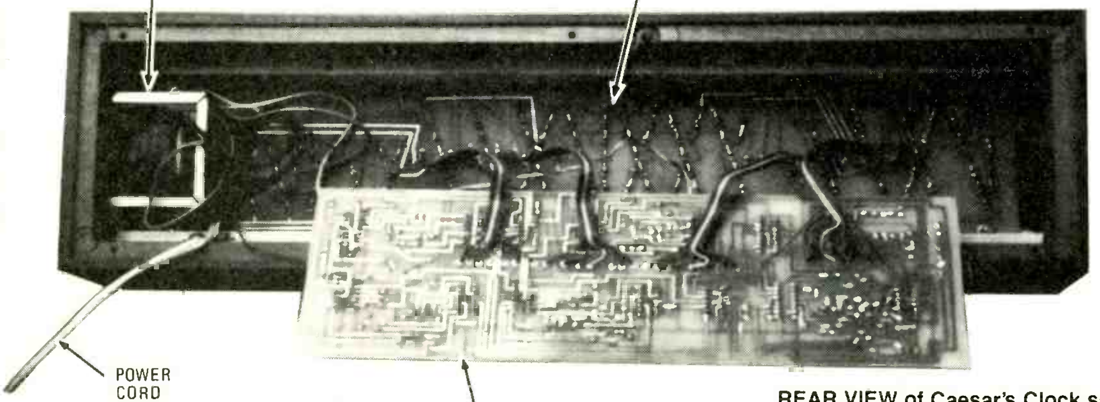
D1-D4, D88-D95—1N4002 rectifier diodes
D5—1N4744A 15-volt Zener diode
D6-D87—1N4148 signal diode
LED1-LED177—Light-emitting diode
U1, U2, U5, U8, U11, U12—4017 CMOS synchronous divide-by-10 counter with 1-of-10 outputs integrated-circuit chip
U3, U4, U7, U10, U13—75492 hex inverting buffers integrated-circuit chip
U6—4070 CMOS quad exclusive OR gate integrated-circuit chip
U9—74C14 hex Schmitt inverting triggers integrated-circuit chip
U14—4024 CMOS 7-stage (divide-by-128) binary ripple counter integrated-circuit chip

ADDITIONAL PARTS AND MATERIALS

C1—50-μF, 25-WVDC electrolytic capacitor
C2—.01-μF, 25-WVDC disc capacitor
R1—30,000-ohm, ¼-watt resistor
R2-R6—1 Megohm, ¼-watt resistor
R7—220-ohm, ¼-watt resistor
R8—100 ohm, ¼-watt resistor
S1-S3—Mercury tilt switches
T1—Transformer: 117-VAC primary winding; 10-VAC, center-tapped, 1-A secondary winding
Logic and display printed circuit boards, power cord, wood case, high-contrast filter bezel for front panel, wood case, wire, solder, hardware, etc.

At the present time the author is preparing for sale the printed-circuit boards and a kit of parts. Should you be interested in obtaining a list of materials with prices, send a stamped, self-addressed envelope to: Harry Landis, 207 Oak Street, Norton, MA 02766.

FIG. 4—SHOWN ON THE LEFT are the foil patterns for the display printed-circuit board reduced to fit the height of the page. This long dimension must be enlarged to 17½ inches when making the foil patterns on the same board. Otherwise, the details for making the board are the same as the logic printed-circuit board.



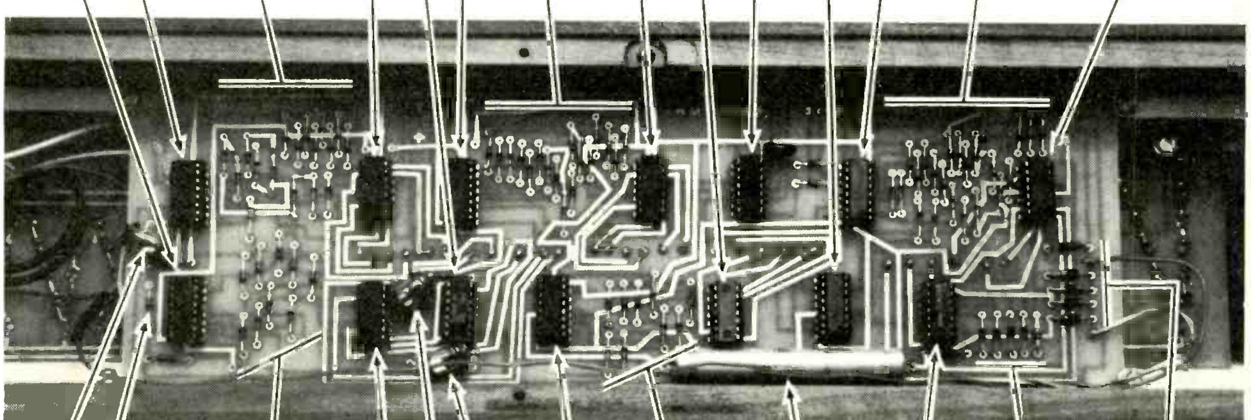
REAR VIEW of Caesar's Clock showing the logic printed-circuit board removed. The interconnections between the two boards are made by ribbon cable which permits easy access to the display printed-circuit board. Since lead length is not critical, this wiring technique is desirable.

Now is the time to check out visually the operation of the mercury switches, S1 through S3. You need not power up the unit. Instead, the mercury switch contacts and the pool of mercury are visible through its glass enclosure so that you can see when switch contact is made. Refer to the next paragraph in this article to determine when the switches should close. The exact angle at which action takes place is not critical; just mounting the mercury switches on the board will determine the angle of switching. Now would be a good time to check the soldering connections and diode polarity on each printed-circuit board and save hours of troubleshooting later on. Check that the different types of circuit chips are installed where they should be, and that their positioning is correct.

Operation

To operate Caesar's Clock, it is plugged into a wall outlet that provides 110-120-volt, 60-Hz, AC power. The display will be illuminated and the correct time may be set. That is done by tilting the clock about 30 degrees to the left (in effect lowering the left side of the clock from the position it normally stands) to advance the minutes at a rate of one minute per second. Tilting the clock about 75 degrees to the left will advance the hours at a rate of one hour per second. Tilting the clock about 45 degress to the right will reset the seconds display to zero and will inhibit counting.

In case you do not know, Julius Caesar did use a clock, but it was unlike anything we use today. Caesar kept a water clock which was very much like the clocks used by the Chinese many centuries earlier. He may have called his time machine a *clocca*. Other clocks of the period were simple devices devoid of all mechanical levers, gears, and springs. A candle clock, a common item, was marked along its length to indicate hours. You can be sure that Caesar's clock of yesteryear had Roman numerals on it as does your modern version. **SP**



PARTS LOCATION DIAGRAM for the logic printed-circuit board has been simplified by grouping large numbers of identical diodes in small areas. Check Fig. 1 for diode types and polarity before installing and soldering on board. With the board held in the position shown above, the integrated circuit-chips are mounted with their respective notches nearest the bottom of the page.

STEREO MULTIPLEX ADAPTER

LAWRENCE G. SOUDER

You can easily convert your mono-FM table radio to drive a stereo headset for bedside listening!

YOU SAY YOU'D LIKE ONE OF THOSE NEW PERSONAL STEREO FM radios, but you can't justify the purchase of another radio because you already have two table models, three portables, and one clock radio? Well, you can have that new stereo feature—without adding yet another appliance to your collection—by converting one of your existing FM radios with this Stereo Multiplex Adapter. You could, in fact, turn that old clock radio into a *clockman*.

That simple, inexpensive project provides true stereo reception through light-weight headphones from a monaural FM receiver. The Stereo Multiplex Adaptor is a simple project because it takes advantage of the high technology of linear integrated circuits that can implement whole functions like audio amplification and FM-stereo demultiplexing on one chip. Specifically, that project is built around the LM1800 phase-lock-loop (PLL) FM stereo demodulator chip.

What is Multiplexing?

Before looking at how the Stereo Multiplex Adapter works, let's review the theory behind FM-stereo multiplexing. Multiplexing, in general, means transmitting more than one message over the same medium. As it applies in particular to FM broadcasting, multiplexing means transmitting two discrete channels, left and right, on the same RF carrier.

Figure 1 shows how an FM-stereo broadcast station creates its multiplexed signal. The left and right audio channels are combined in two ways. First, they are added together to produce an L + R signal, which spans the usual audio-frequency range of 30 to 15,000 Hz. Then, the right channel is inverted before being added to the left channel again, that time to produce an L − R signal. In the meantime, an oscillator is continuously producing a 19-kHz signal which is doubled to 38 kHz. That 38-kHz signal and the L − R audio feed a balanced modulator to yield an L − R double-sideband signal whose frequency now ranges from 23 kHz to 53 kHz. The balanced modulator also cancels out the 38-kHz carrier. Finally, those three signals, the 30 to 15,000 Hz L + R monophonic signal, the 23-kHz to 53-kHz L − R signal, and the 19-kHz pilot signal all are used to frequency-modulate the radio-frequency carrier signal where three messages ride on the same medium.

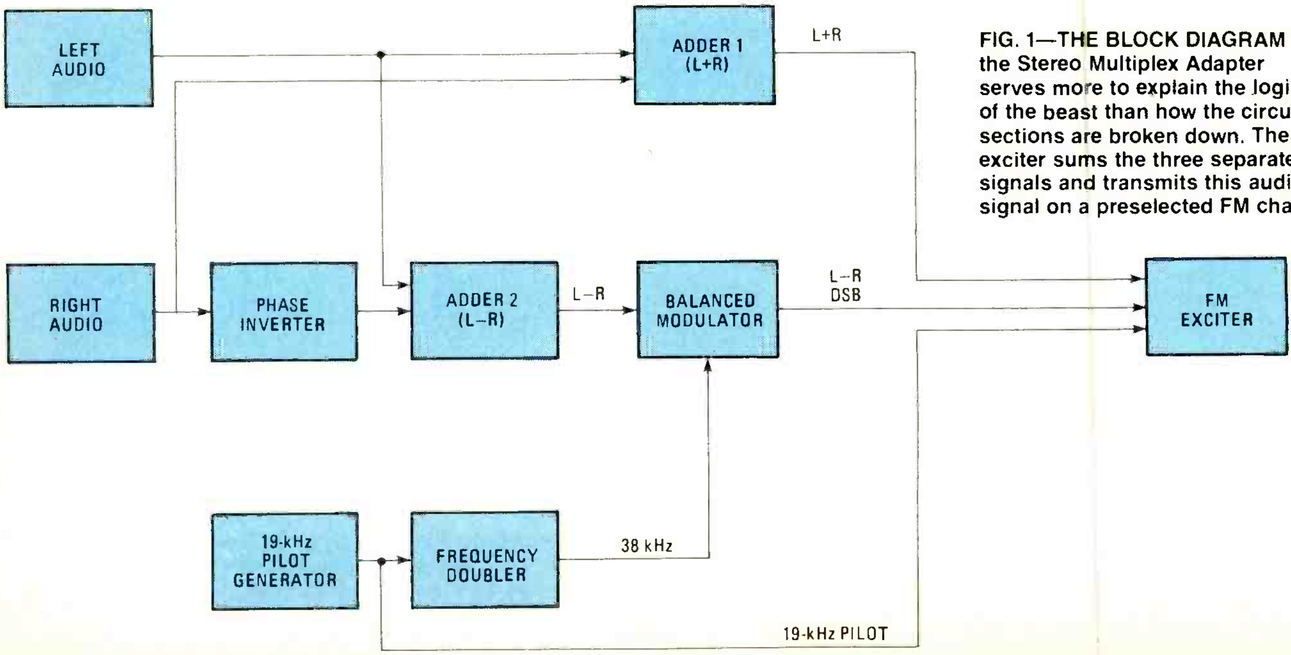


FIG. 1—THE BLOCK DIAGRAM for the Stereo Multiplex Adapter serves more to explain the logic of the beast than how the circuit sections are broken down. The FM exciter sums the three separate signals and transmits this audio signal on a preselected FM channel.

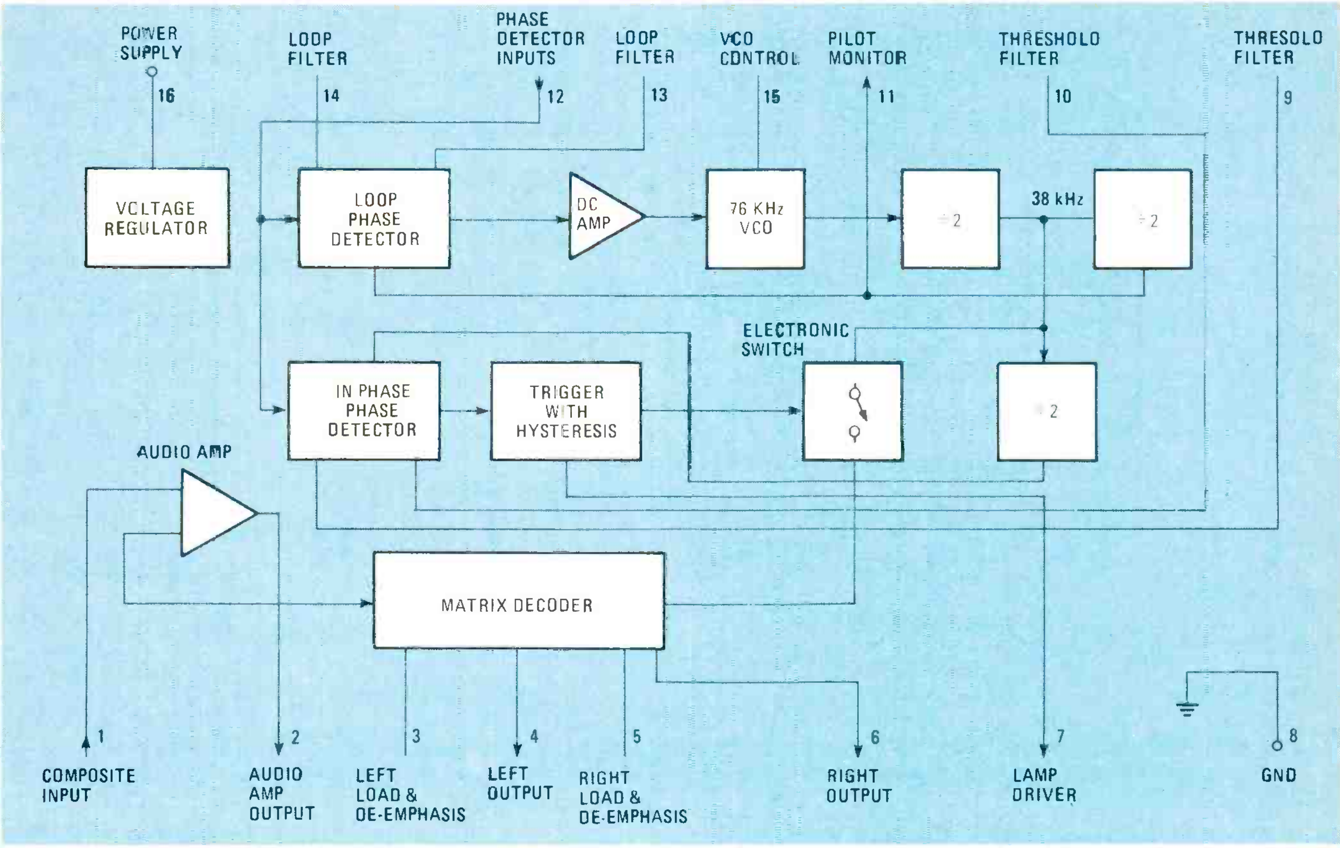
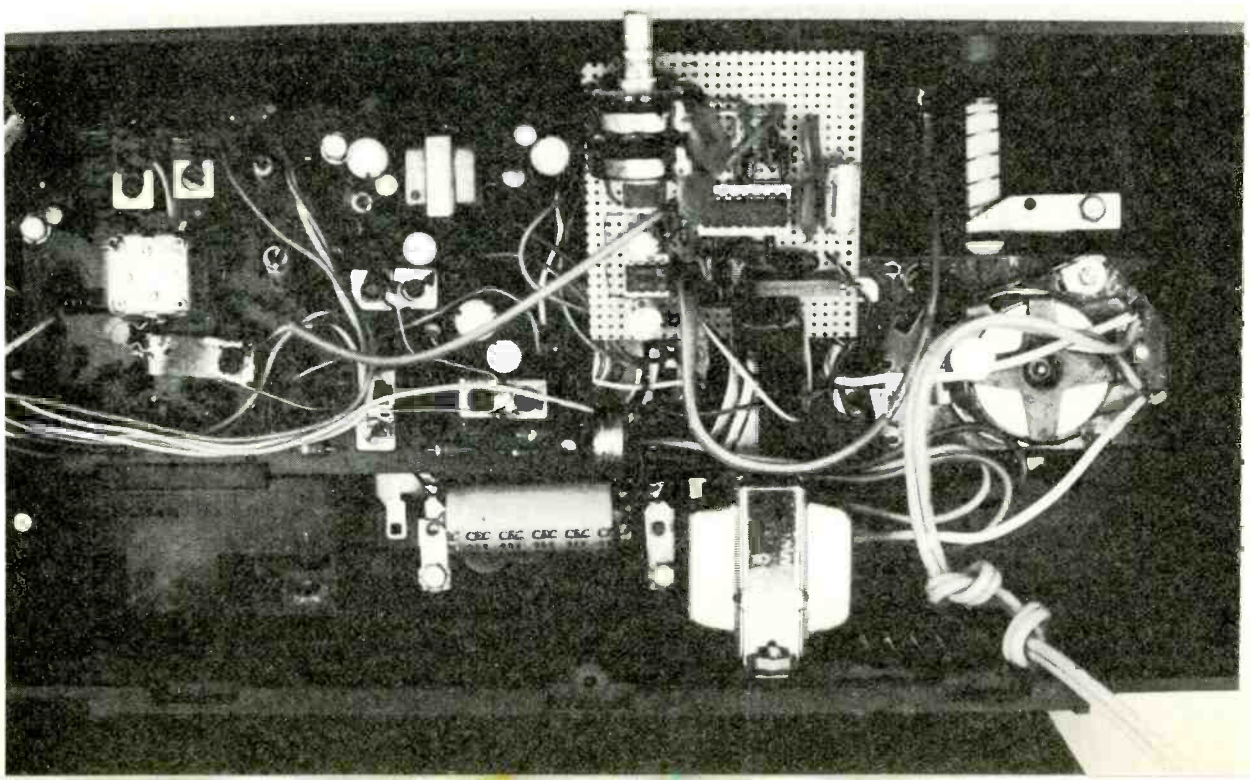


FIG. 2—THE PHASE LOCK CHIP, LM11800, is the golden device that makes this project possible. Chip technology placed a table-top's worth of circuitry into a DIP-sized chip. Without this chip, most phase-lock-loop, consumer receivers would not be in existance today. FM stereocasts would require noisy, troublesome circuitry of the '50's.

What is Demultiplexing?

To demodulate the signal generated at the transmitter, the adapter must reverse the multiplexing process, or demultiplex the signal. When an FM receiver is tuned to a stereo station, the output of its audio-level detector contains the 30-Hz to 15-kHz L + R, the 23-kHz to 53-kHz L − R, and the 19-kHz pilot-signal components. If the receiver is the monaural type, only the L + R component is processed at the detector. Thus, FM-stereo broadcasts are compatible with monaural receivers. A simple high-frequency bypass circuit eliminates

THE SQUARE PIECE of perfboard mounts all the add-on components for the Stereo Multiplex Adapter. When the board is mounted in the FM radio, the volume-control knob will extend outside the cabinet for user adjustment.



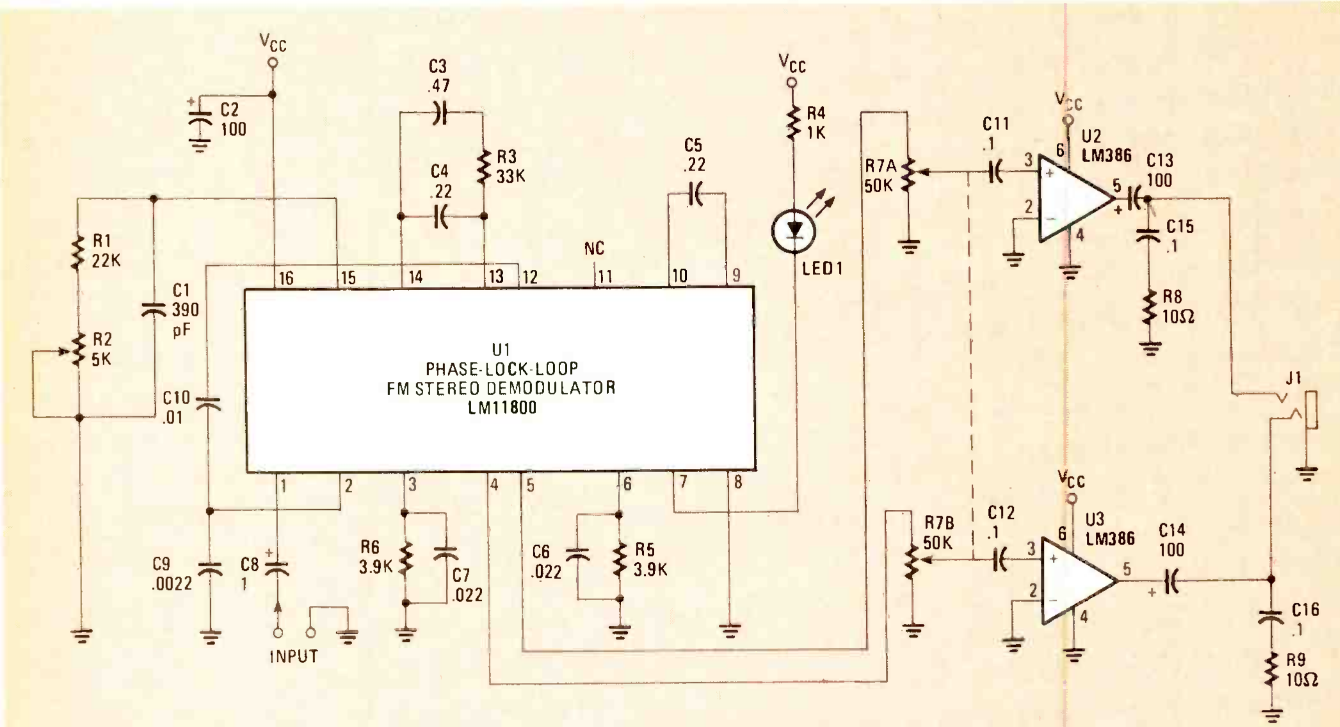


FIG. 3—COMPLETE SCHEMATIC DIAGRAM for the Stereo Multiplex Adapter is show in above. The twin LM386 outputs drive the left and right channels of stereo headphones as if the receiver were a unit priced at least $100 more.

the 19-kHz pilot and L − R signals so as not to overload the audio-amplification circuits if they should have a very broad frequency spectrum.

If the receiver is capable of stereo reception, all three signal components are processed. Now, before the L − R signal can be used, its frequency must be brought back down to the audio range by demodulation. Since it is a double-sideband (DSB) signal with no carrier, the demodulation process requires re-inserting the 38-kHz carrier. At that point the 19-kHz pilot signal comes into play. That signal is doubled in frequency to become the 38-kHz carrier. After demodulation the L − R signal is back to the audio range. Then, the L + R and L − R signals are combined in a matrix decoder, a circuit which both adds and subtracts those two signals. The addition of L + R and L − R yields a 2L signal which becomes the left-channel audio, while the subtraction of L + R and L − R yields a 2R signal which becomes the right-channel audio.

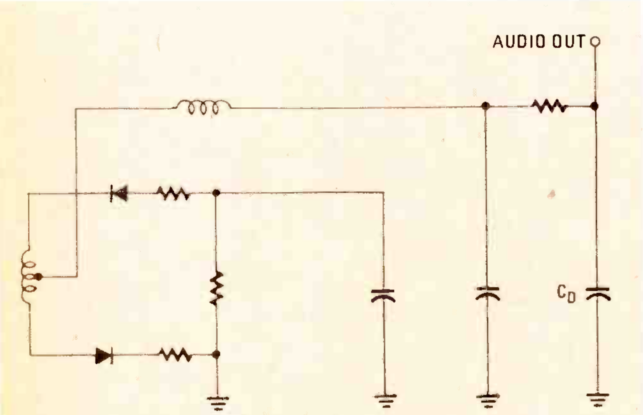


FIG. 4—TYPICAL FM DETECTOR CIRCUIT found in most home-entertainment, FM receivers is diagrammed here. Capacitor C + sbD must be removed from the circuit in order for the Multiplexer Adaptor to work properly. This capacitor is part of the de-emphasis network that rolls off the highs to restore a flat, audio-frequency response.

The LM1800

The LM1800, which the Stereo Multiplex Adaptor is built around, provides a simple and inexpensive way of demultiplexing the FM-stereo signal. That integrated circuit is quite complex with hundreds of transistors, but its block diagram in Fig. 2 makes its demultiplexing process easily understood.

Pin 1 of the LM1800 accepts the composite audio signal from the ouput of the FM-radio detector. An audio amplifier passes that signal on to the matrix decoder and pin 2.

Pin 2 of the LM1800 is usually externally connected back to pin 12, the phase-detector inputs, one of which is the in-phase phase detector. It is that block of the LM1800 which combines a 38-kHz carrier and the (23-kHz to 53-kHz) L − R signal to bring its frequency back down to the audio range.

The 38-kHz carrier itself is a product of a phase-locked loop system consisting of the blocks labeled loop-phase detector, DC amp, 76 kHz VCO, and two divide-by-two stages. Once the L − R signal has been converted back down to the audible 30-Hz to 15-kHz range, it is gated via the trigger and electronic switch into the matrix decoder where, in conjuction with the L + R signal coming directly from the audio amplifier stage, the separate left and right channel audio signals are recreated.

About the circuit

The schematic diagram in Fig. 3 shows the simplicity of the multiplex adapter. The LM1800 is wired up in a conventional manner, and it feeds separate audio amplifiers, U2 and U3, which drive a set of stereo headphones. Power-supply requirements are 10-18 volts for the LM1800 and 4-15

PARTS LIST FOR STEREO MULTIPLEX ADAPTOR

SEMICONDUCTORS

LED1—light-emitting diode
U1—LM1800 phase-lock-loop FM stereo demodulator chip
U2,U3—LM386 .4-watt audio amplifier chip

CAPACITORS

C1—390-pF, ceramic
C2,C13,C14—100-μF, 16-WVDC electrolytic
C3—.47-μF
C4,C5—.22-μF
C6,C7—.022-μF
C8—1-μF, 16-WVDC electrolytic
C9—.0022-μF
C10—.01-μF
C11,C12,C15,C16—.1-μF

RESISTORS

(All fixed resistors are ¼ watt, 5% or 10% unless otherwise noted)
R1—22,000-ohm
R2—5,000-ohm, trimmer potentiometer
R3—33,000-ohm
R4—1,000-ohm
R5,R6—3,900-ohm
R7—Dual 50,000-ohm, audio-taper potentiometer
R8,R9—10-ohm

ADDITIONAL PARTS AND MATERIALS

J1—Miniature, stereo, phone jack
Perfboard, 16-pin DIP socket (optional), knob, wire, solder, etc.

volts for the LM386, so a common V_{CC} can be used. In fact, the existing power supply in the host radio should be adequate.

As seen in the photo, construction on perforated board is easy, and inexpensive as well. Just keep the wiring short and neat, because much of the circuitry handles low-level signals which can allow for hum and noise interference. Beyond that, many of the construction details will depend upon your particular host radio.

Making It Up

To install the Stereo Multiplex Adapter in your FM radio, only input-detected audio, power, and ground connections are necessary. If you decide to steal power from the host radio, check the following items: First, make sure that the power supply is within the voltage requirements of the LM1800 (i.e. about +12 volts). Second, ensure that the power supply has adequate filtering (at least 1000-μF). Next, verify that the voltage is the correct polarity with respect to ground. That adapter circuit must have a positive V_{CC} whereas some radios may have a negative power supply. Finally, check to see whether your radio is a hot-chassis type. If it is, take the time and expense to install an isolation transformer because the adapter will expose the user to the radio's circuit ground via the headphone-shield lead—a direct path to the hot AC line.

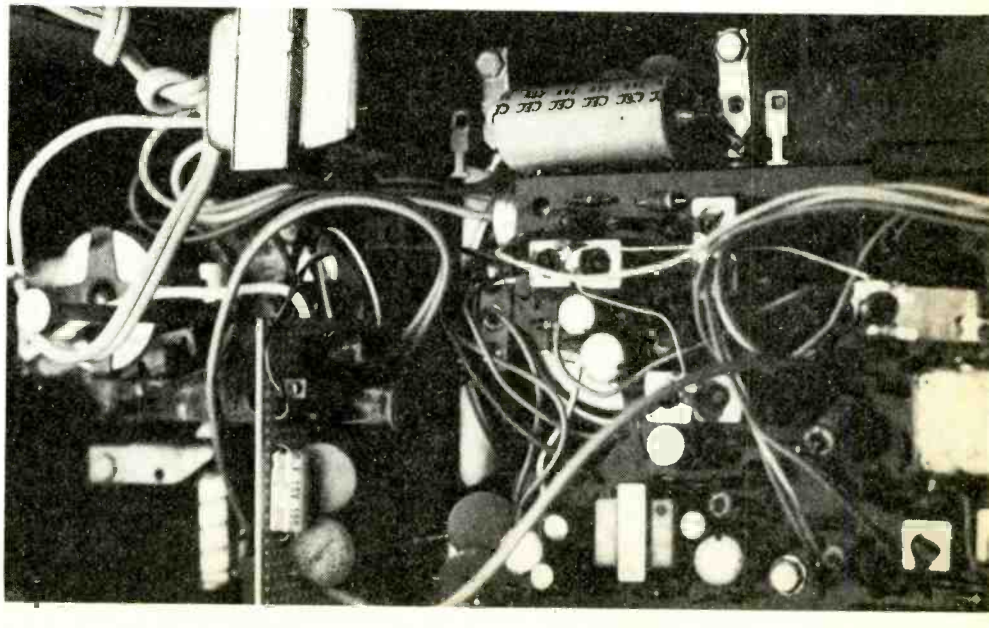
To connect the Stereo Multiplex Adapter to your FM radio for input signal, you must locate the FM-detector. Figure 4 shows a typical FM detector circuit, although it is best to consult the schematic diagram for your particular set. Once you have found the detector, isolate the de-emphasis network, usually a shunting capacitor like C_D across the signal path, and disconnect it. That is necessary, because de-emphasis acts like a low-pass filter which may attenuate the higher frequency L − R audio component and the 19-kHz pilot signal. Now connect the detector output via a shielded cable to the signal input of the adapter.

Alignment

Since there is only one adjustment on the adapter, alignment of that unit is very simple. First, tune in an FM-stereo station through the headphones, and adjust potentiometer R2 until the LED lights. That may already have occurred without any adjustment. The stereo effect should be obvious now in the headphones. The LED will indicate a stereo broadcast.

Fighting Back

The Stereo Multiplex Adapter project shows that you needn't be at the mercy of the consumer-electronics industry. If you want a new feature or accessory, rather than buy a new appliance, you can update your old one by means of the high technology of integrated circuits. **SP**



THE MULTIPLEX ADAPTER perfboard is visible in the photo at left in the lower-left area. Most table-top FM receivers have room enough for a small square of perfboard to tuck away in some area. Leads were kept just long enough to make connection with the perfboard resting on top of the receiver. Take notes on what must be done to restore the receiver to its original wiring and tape to bottom of receiver. Do not cover any ventilation holes.

YEP! THAT'S A REAL typewriter keyboard on a Color Computer. Just part of a relatively low cost, easy-to-do upgrade that turns CoCo into a deluxe computer.

DELUX CoCo

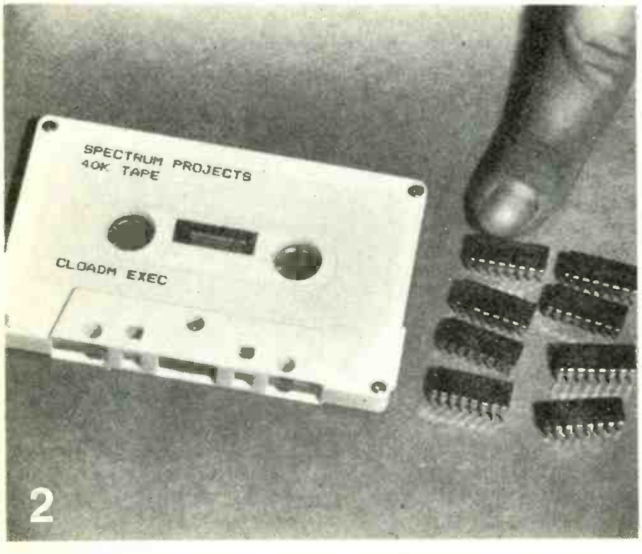
Your personal computer experiences begin at the keyboard. Why not make it a pleasant experience?

IN LESS THAN AN EVENING AND FOR MUCH LESS MONEY than the factory service would charge, virtually anyone who has built small electronic projects, fixed a few appliances, or just knows one end of a screwdriver from the other, can upgrade a Radio Shack Color Computer into a full-featured high-performance personal-computer system.

The Radio Shack Color Computer—affectionately called the *CoCo*—is often touted and sold as a *beginner's* or *entry-level* computer. In fact, The CoCo packs a lot of potential high-powered performance: enough to run professional quality word processing, database, "What If...? (Calc-type), and communications software. As many *hardware hackers* were quick to discover, Radio Shack had built in a lot more features than they were admitting. It was almost as if they had planned to sort of sneak a *full-blown* computer into the home by way of an inexpensive, entry-level computer which could be easily upgraded when Radio Shack was ready to do the upgrades.

The early versions of the CoCo came with 4K or 16K of RAM, and an elementary, though decent, version of BASIC. 32K RAM upgrades were available from Radio Shack at considerable cost. Even if you were satisfied with 4K or 16K of RAM, the latest *pro quality* software required at least 32K, while the new OS-9 DOS (Disk Operating System) for the CoCo requires 64K of RAM. So for serious, professional, or high-performance computing you faced rather expensive factory-service upgrade costs.

If you're not into a disk drive yet, a 64K upgrade will result in 40K-available RAM if you use a low-cost utility that we will describe later. The utility is needed because the BASIC



THESE EIGHT 64K RAM's are the only components used for the RAM upgrade. The optional cassette utility software provides 40K of RAM for general use.

THE KEYBOARD is supplied as a complete factory-assembled unit that has been pretested. It is a direct substitute for the original *Chiclet* keyboard.

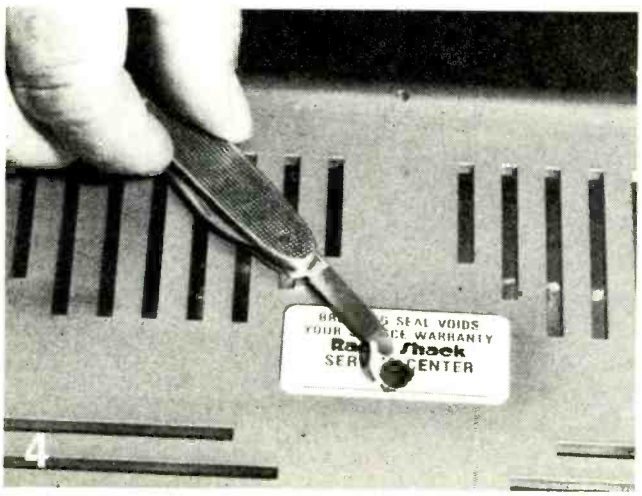
doesn't *see* the extra 32K of RAM. Some third-party software, such as the Telewriter-*64* word processor and Nelson communications software, will automatically use the maximum available RAM.

Upgrading the RAM yourself is a rather easy job that produces considerable cash savings. For example, a 64K upgrade from 4K, 16K, or 32K will cost you about $150 plus installation through Radio Shack. Should you do the job yourself, the 64K chips and installation instructions will cost you only $49.95 from Spectrum Projects, 93-15 86th Drive, Woodhaven, NY 11421. The Spectrum Projects' 64K-RAM upgrade kit consists of eight integrated circuits and two pages of brief, but rather clear instructions.

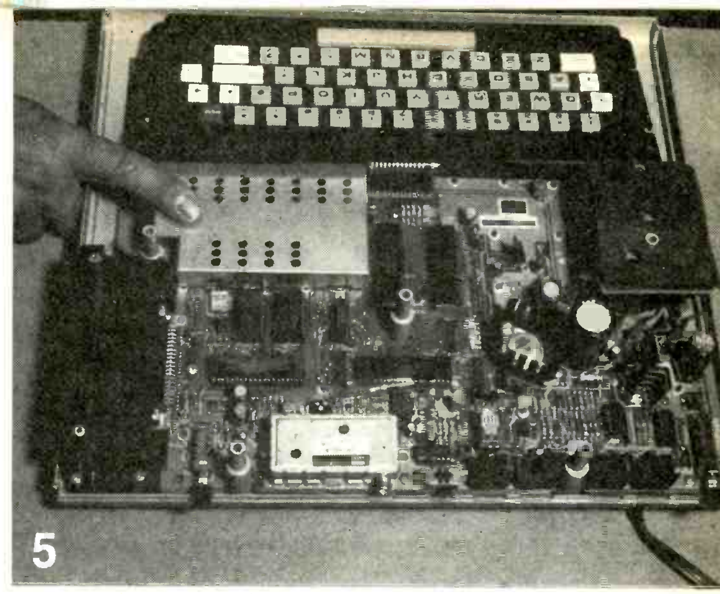
Before we get into the how-to-upgrade-your-CoCo's-RAM chit chat, let's take time out to consider another upgrade you should do at the same time: the keyboard. The CoCo has a *Chiclet* keyboard, meaning the keys resemble small squares of *Chiclet* chewing gum, and they have a very slight travel—almost a *Hair trigger*. As those keyboards go, the CoCo's isn't too bad, but a *Chiclet* isn't the equal of a real typewriter key. A heavy session of word processing or BASIC programming on Chiclet keys can be rather tiring on the fingers. There's actually no need to put up with that inconvenience, because one of the easiest CoCo upgrades is a keyboard having full-size, full-travel typewriter keys (see Photo 1). Full-travel is the important consideration here, because some typewriter-style keyboards are nothing more than a full-size key with a *Chiclet* short-stroke mechanism, and those keyboards don't have the feel of a real typewriter keyboard.

There are several typewriter-keyboard upgrades for the CoCo in the marketplace. Among the best is the HJL-57 ($79.95), which is also sold by Spectrum Projects. The HJ-57 uses DAK switches (a recognized name in switches), and the keyboard assembly is a perfect drop-in replacement fit for the existing keyboard. It's a *no-hassle* upgrade. See Photos 2 and 12.

Anyway, back to how-to-do-it. If you follow the text while referring to the photographs, you'll see just how easy it is to add both the RAM and keyboard upgrades. But, before we start, a word of caution: Do *not* do both upgrades at once, because if you make an error you won't know where you went wrong. Do the RAM first, make sure that the computer works with the original keyboard, then install the keyboard. Note:



ONE OF THE SCREWS that holds the cabinet together is concealed beneath the warranty seal. Simply lift part of the seal out of the way with a knife to get at the screw.



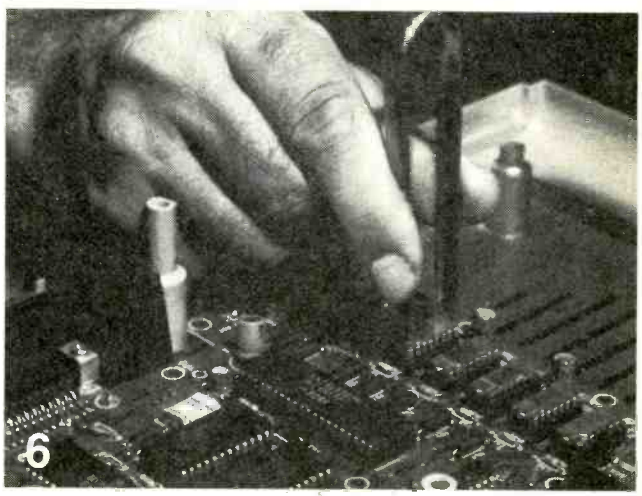
THE FINGER POINTS to the shield that covers the RAM. It is secured by tabs passing through the board that are folded on the underside. Straighten tabs to remove shield.

In some photos the keyboard was removed in order to show the RAM upgrade more clearly.

To protect the MOS computer devices from being damaged by static electricity, handle all computer parts—in particular the replacement RAM's—only when you are grounded through a *ground strap*. To make a ground strap, connect a small alligator clip to one end of about 10 feet of thin, flexible wire. Solder a 1-Megohm, ½-watt resistor to the other end of the wire and then attach the free end of the resistor to an electrical ground, such as the screw that secures an electric receptacle's cover plate (the screw to which you make connection when you use a three-wire to two-wire receptacle adaptor). Secure the alligator clip to a metal part of your watchband (the ground strap) whenever you work on the computer. If you don't usually wear a wristwatch, wear one anyway when working on the computer so you have a metal part on which to attach the ground clip.

Open Up

The first step in deluxing the CoCo is to get into the computer. Disconnect the computer from the AC line and any connecting cables. Turn the computer upside down and remove the 7 screws that hold the cabinet together. What's



USE AN IC CHIP PULLER when removing the old IC chips to prevent accidental damage to the DIP sockets. Don't pry or flip the IC chips out with a screwdriver.

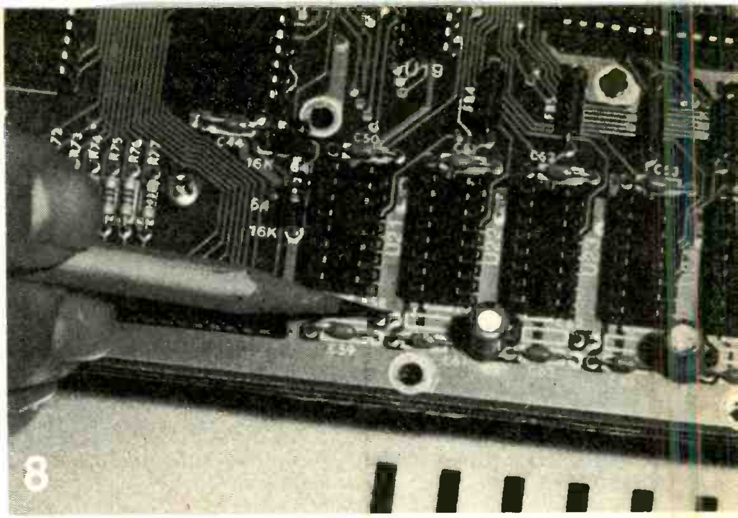
that...you count only 6 screws? The seventh is located under the warranty seal. As shown in Photo 4, peel away the center of the seal with a knife to expose the screw. When all the screws are removed, hold the two parts of the cover together and turn the computer right side up; then gently lift off the top cover.

Locate the metal shield shown in Photo 5. The RAM chips are under this shield, which is held in place by a few tabs that pass through the printed-circuit board and are folded back against the board. If you have thin fingers, reach under the board, straighten the tabs, and gently lift the shield off the board. If you have large fingers and can't get them under the board, remove the screws that secure the board to the bottom cover so you can lift the board a few inches. Straighten the shield's tabs, remove the shield, and then temporarily secure the board with one or two screws. Whatever else you do, do *not* disconnect the wires from the power transformer to the board in an attempt to get the board completely out of the cabinet; you might not get them back in the correct order.

The eight RAM's are in a straight line. Using an IC puller (see Photo 6) carefully remove the RAM chips. Use a puller: *don't* try to flip the chips out with a screwdriver because you might damage the socket on the flip. If you don't have a puller, borrow or buy one. You can get a kit consisting of a puller and an IC inserter for about seven dollars at most parts stores.

There are four contact sets which must be programmed before you install the new RAM's. Three are labeled *16K-64K* and have factory jumpers. As shown in Photo 7, simply move them from the 16K to the 64K position. The fourth contact set consists of two side-by-side staking pins labled 64K. If you have a small, plastic jumper lying around, install it on the pins. If not, push the pins together and solder. Use a small soldering iron and make the connection quickly.

Next, using small wire clippers, remove the eight capacitors labled C58, C60, C64, C66, C68, C70 and C72. Those capacitors are located directly at the end of each RAM socket and are clearly identified on the printed-circuit board. But be careful: There are *two* rows of capacitors that look like miniature diodes. You remove the row closest to the socket. The pencil in Photo 8 points to the free space between the sockets and the second row of capacitors that results when



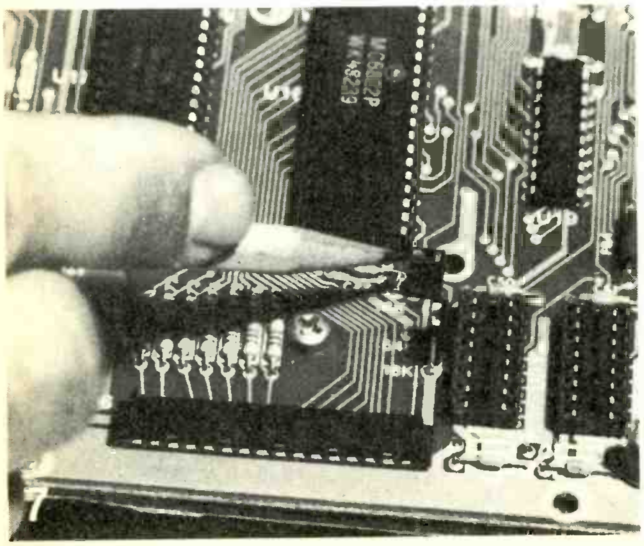
THE EIGHT CAPACITORS to be removed create spaces between the RAM sockets and the next row of capacitors. Don't be fooled; they look very much like miniature diodes.

you remove the correct capacitors. If the capacitor you're going to remove won't create the space, doublecheck what you're doing because you're probably going to cut the wrong component.

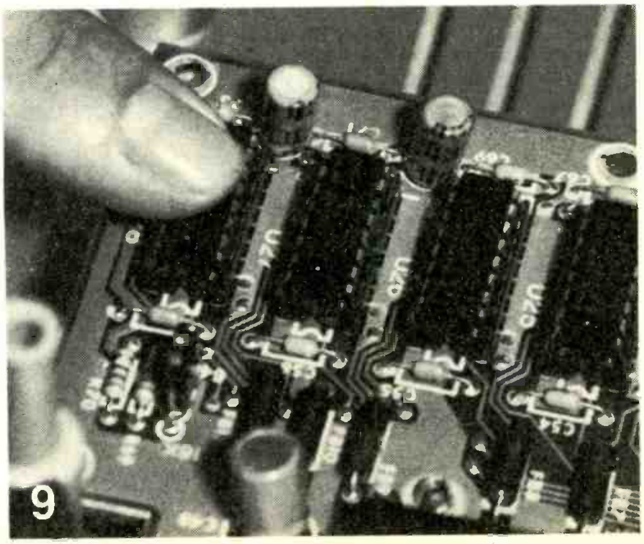
After the jumpers are installed and the capacitors are removed, insert the 64K RAM's. Be careful and make sure that all the pins go into the socket; triple check each RAM to be certain that one, or more, pins have not folded under the body of the IC. Using an inserting tool will sharply reduce the possibility of damaging a RAM through improper installation.

As shown in Photo 9, make certain each RAM is fully seated by pressing down on the body of the RAM with your finger.

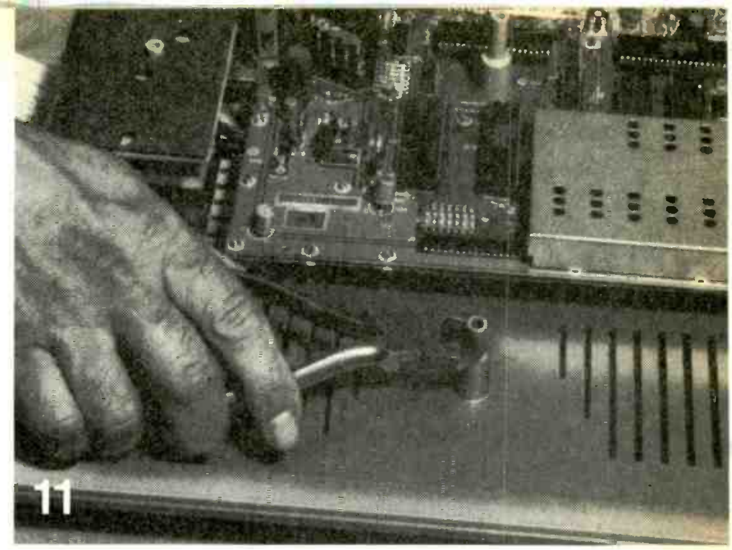
With the cover off, connect the computer to your TV monitor and *power-up*. If all is working correctly, you will get the screen prompt. Entering PRINT MEM (print memory) should produce a screen display of 24,871, which is the free (or user-available) RAM for a 32K system. What happened to the other 32K? The 64K of RAM is divided into two banks of 32K. The first bank is accessed normally by the computer. The second bank can only be accessed through special software such as the OS-9 Disc Operating System, the Telewriter, tape, or disk, word processor, etc. Or, a special $9.95 pro-



THE PENCIL POINTS to one of the three jumpers you must move from the 16K to the 64K position. To find them, look for the 16K-64K designation printed on the board.



MAKE CERTAIN that each RAM chip is fully seated in its DIP socket by pressing down gently with your finger tip. Now is the time to check the IC chip's orientation.



CUT OFF THE TOP of the plastic mounting post located in the center of the keyboard area in order to provide clearance for the keyboard's ribbon cable.

gram called *40K* can be used to relocate part of the 8K extended BASIC so that 40K of RAM is available to the user. Much of the newer CoCo software automatically utilizes the full 64K of RAM.

The next step is to install the keyboard. If you have a *Model D* or *E* computer, the keyboard is connected to the printed-circuit board through a 16-pin connector. Simply separate the connector to disconnect the keyboard from the printed-circuit board. You can tell if you have a *Model D* or *E* by looking at the number in the lower right corner of the board; it will consist of a number ending in the letter *D* or *E*. If you have a *Model F computer, the keyboard is connected through the special ribbon cable shown in the photographs. You can tell if you have a model F* without even opening the computer by looking at the model number printed on the identification tag on the bottom of the computer. If the model number is followed by the letter *A* you have a *Model F*. If there is no letter, the computer is a *Model D* or *E*. Since there are two versions of the replacement keyboard, one for the *D* and *E*, and one for the *F*, make certain that you know which one to order.

To remove the keyboard of a *Model F* computer, as shown in Photo 10, grasp each side of the ribbon directly behind the printed-circuit board's socket and rock the ribbon gently from side to side as you ease it out of the socket. Then just lift the keyboard out.

When the keyboard is removed, install the RAM shield and secure the printed-circuit board to the cabinet using all the screws you originally removed. Do not go on to the remainder of the keyboard installation until the shield is in place.

As shown in Photo 11, using diagonal cutters, clip the top off the post located in the center of the keyboard area. That will provide the necessary clearance for the connecting ribbon of the new keyboard that comes out the front of the keyboard and is tucked under to the socket. Do not attempt to install the keyboard without cutting the post.

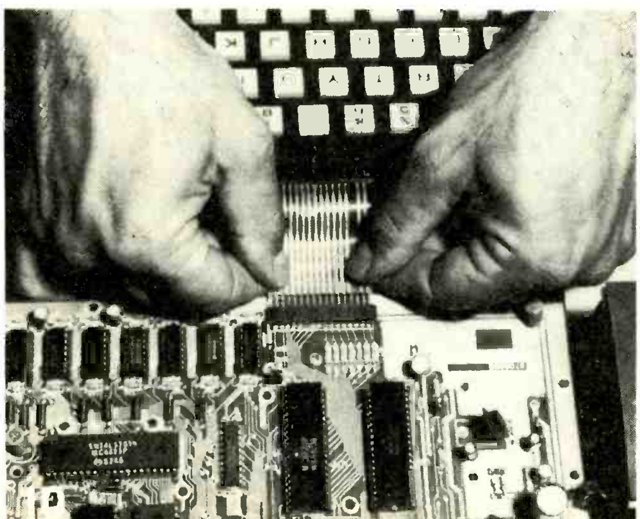
Make sure that you have the ribbon cable from the new keyboard correctly oriented (no twists or turns), grasp both sides, and wiggle it from side-to-side as you gently ease it into the socket. Then move the keyboard itself into position above the plastic posts and let it drop onto the posts. Secure the keyboard to the posts with the supplied washers and speednuts as shown in Photo 12.

Before closing up (sounds like surgery), check the keyboard installation by running the computer. Make certain that every standard key does what it is supposed to do. If pressing the keys have no effect, or you get garbage, disconnect the computer's power cord and make sure that the ribbon cable is seated properly in the socket.

The keyboard has four function keys—labeled F1, F2, F3 and F4—which have no inherent purpose. They can be used within programs you write, or they might be used in programs published in the magazines that cater to Color Computer users.

When you are satisfied that the computer and the keyboard functions properly, install the new keyboard bezel in the computer cover using the supplied speednuts, position the cover over the keyboard, and close up using all seven screws to secure the cabinet.

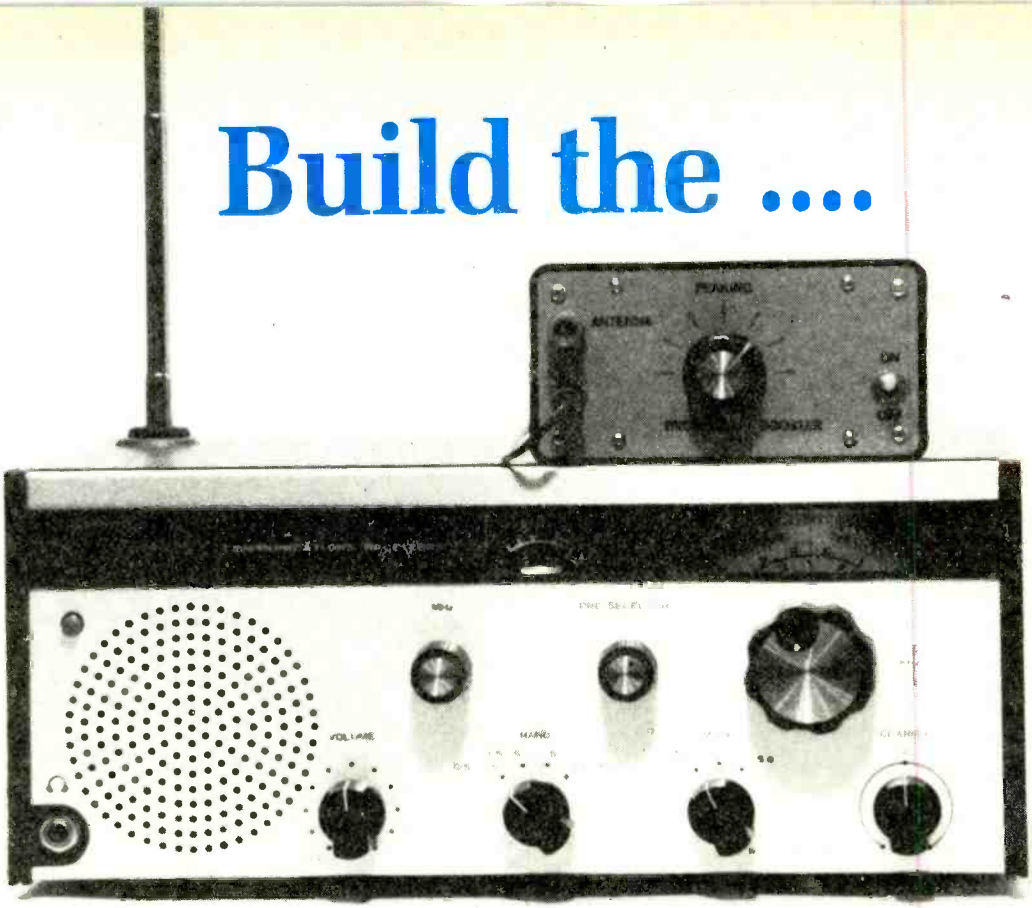
That's the whole bit. Simple and easy to do. It seems a lot more difficult in reading than it really is. Both the RAM and keyboard upgrade can take as little as a half hour to complete, or an hour at most if you're extra careful. In the end you wind up with a deluxe version of the CoCo that is able to handle the most elementary, or sophisticated, software. **SP**



TO REMOVE the keyboard ribbon cable from a model F computer, grasp the cable on both edges at the connector and wiggle it gently to ease it out of the socket.

POSITION THE KEYBOARD over the plastic posts and let gravity do its work—gently. Secure the keyboard in place with the speednuts supplied with the kit.

Build the ....



Broadcast Booster

YOGI BERRA, THE LIVING, LEGENDARY YANKEE CATCHER, baseball manager, and coach is also famous for his aphorisms which take a few seconds to fully comprehend, such as "You see a lot when you watch", and "The game isn't over till the last out." If he were talking about DX'ing, or shortwave listening (SWL'ing), Yogi would probably state "You can't hear 'em if you can't hear 'em."

Whether your receiving antenna is an umpty-ump foot skyhook stretching to the next horizon, or 10 feet of zip cord on the living room floor, whether your receiver is a $19.95 bank gift or a gold-plated special almost as expensive as a new car, there's always one more DX signal you could hear if you had just a wee bit more receiver gain.

You can get that extra gain with our Broadcast Booster, a tuned, RF preamplifier (see Fig. 1) that adds about 20 dB of extra gain between the antenna and the receiver when DXing the broadcast band, and that's enough extra gain to pull in a station where there used to be a *dead spot* or just noise.

No, the Broadcast Booster can't create a signal where none previously existed; if there was no station whatsoever on the frequency, the Booster will still produce a dead spot. But if there's a signal way down in the noise level, the Broadcast Booster can often pull it out of the electronic hash to a *readable* level.

The Broadcast Booster tunes and boosts the broadcast band from about 550 to 1400 kHz. It is intended for use with a short, or long-wire, antenna which connects through a multi-way binding post. Its output connects through a short length of coaxial cable (about 30-inches maximum), such as RG-174/U or RG-58/U, to the receiver's antenna input terminals. A special circuit modification provided by a jumper wire allows the use of a separate antenna ground, or a *balanced* antenna having both feeders above ground.

The Booster is powered by a standard 9-volt, transistor-radio battery. The low current requirement of nominally 2 milliamperes DC allows for several months of use in typical operation (a few hours per day). An alkaline-type battery might last up to a year.

Construction

Except for the antenna and output connectors, and the power switch, the Booster is assembled on a 2⅜ × 3¼-inch printed-circuit board (Fig. 2) that can be dropped as a unit into virtually any enclosure—metal or plastic. A copper-foil

HERB FRIEDMAN

Pull that weak station out of the electronic muck and mire to a DX-quality listening level

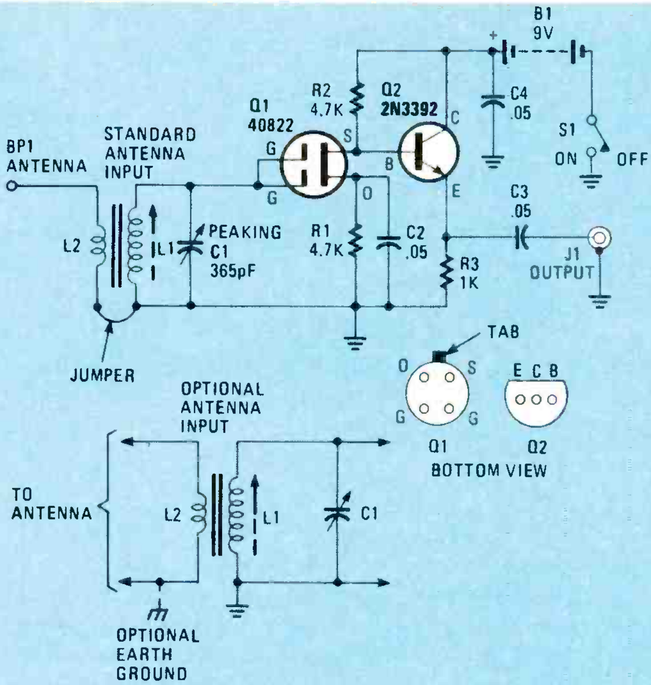
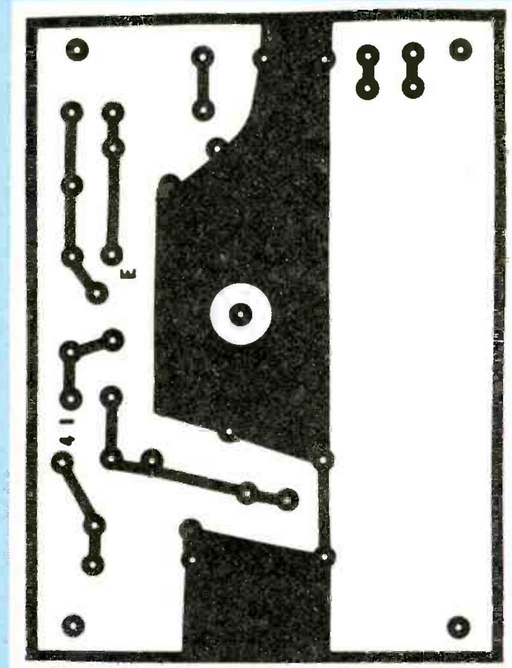


FIG. 1—HERE IS THE COMPLETE schematic diagram for the Broadcast Booster. The field-effect transistor, Q1, and transistor, Q2, must not be substituted by other devices. The Broadcast Booster circuit parameters are designed for those semiconductors. To increase the antenna system efficiency a smidge, remove the jumper in the ground circuit and connect the bottom of the antenna coil, L2, directly to a good earth ground.

FIG. 2—THE PRINTED-CIRCUIT board foil-pattern diagram is presented here at the same size so that it can be copied directly should the experimenter prefer to make his own board. Do not make any design modifications. Information in the Parts List offers beginning experimenters the opportunity to purchase a low-cost, etched, printed-circuit board



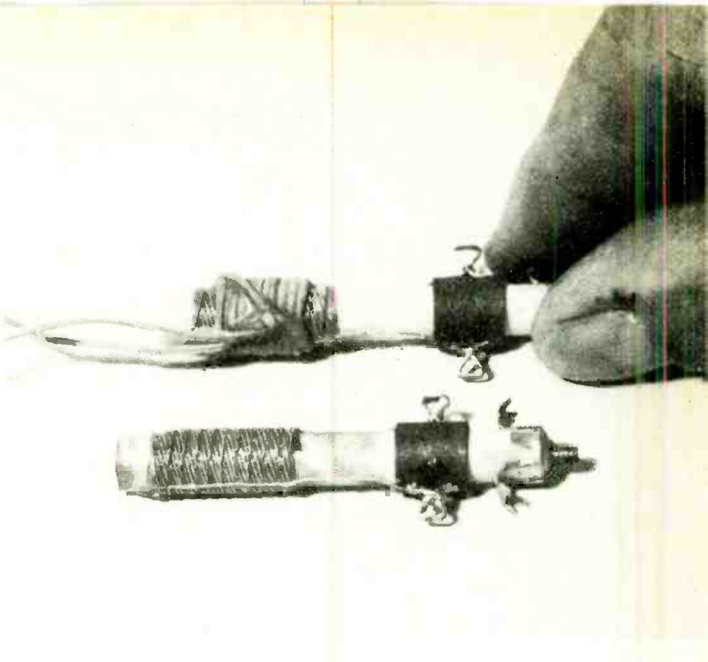
ground shield on the printed-circuit board reduces hand-capacity effects should you use a plastic rather than a metal front-panel. The unit shown was assembled on the aluminum panel of a $2\frac{5}{8} \times 1\frac{5}{8} \times \frac{5}{16}$-inch plastic utility box (Radio Shack 270-233). It makes for a nice, compact accessory.

Because of the Booster's unusually high gain, it is subject to instability should the wiring be sloppy. While the printed-circuit board isn't exactly critical, try to follow the copper-foil template as closely as possible, taking care that you don't eliminate the ground *lands*. Make *no* substitutions for transistors Q1 and Q2—do not use *general replacements*. If you can't get the specified parts, don't build the project. Refer to Fig. 3 for parts location.

The resistors are ½ or ¼-watt at 10% tolerance. No good purpose is served by substituting a higher-quality resistor. Similarly, capacitors C2, C3 and C4 are standard disc or Mylar; silver mica won't result in better performance. PEAKING capacitor C1 is a miniature 365-pF *polyvaricon* tuning capacitor. If you have one of the older 270-pF miniature capacitors in your junkbox, you can use it. The printed-circuit board template makes provision for a *bulk* capacitor needed for the 270-pF variable. We'll cover the capacitor modification later. Refer to Fig. 3 to install components.

PALM-SIZED AND BATTERY POWERED, the Broadcast Booster puts at least 20 dB of extra tunable gain between the antenna and the receiver. The uncluttered front-panel indicates how easy this project is to use.

THE TUNING COIL shown before and after. The unmodified coil is in the foreground. The fingers hold a like coil with the homebrew L1 input link added. Note that L2 is centered on the original winding.



PARTS LIST FOR BROADCAST BOOSTER

SEMICONDUCTORS

Q1—40822 field-effect transistor (FET)—do not substitute
Q2—2N3392 transistor—do not substitute

RESISTORS

(All resistor are ½ or ¼-watt, 10%)
R1, R2—4700-ohm
R3—1000-ohm

CAPACITORS

C1—365-pF miniature polyvaricon tunable
C2, C3, C4—0.05µF disc or Mylar, 10-WVDC

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor battery, type 2U6 or equivalent
BP1—Multi-way binding post
J1—RCA phono jack
L1—Miller 6300 adjustable antenna coil
L2—Coil wound on L1 (see text)
S1—SPST miniature switch
Battery terminals, *#24 or #25 wire*, plastic cabinet with aluminum panel, *wire, spacers, hardware, solder, decals, etc.* (Items in italics not supplied in kit below.)

WHERE TO BUY

A parts kit for the Broadcast Booster containing all of the above listed components, and a drilled and solder-coated, printed-circuit board is available for $30 from Specialty Parts, Box 22, West Hempstead, NY 11552.

The printed-circuit board alone is available for $12.

Prices include postage, handling and insurance. Canada and foreign orders add $1—all funds US. New York State residents must add appropriate local sales tax.

Holing out

The holes for the components can be made with a #55 or #56 drill, while the tuning capacitor requires a 5/16-inch drill. The polyvaricon tuning capacitors usually available in the marketplace have stub shafts which are not long enough for a standard knob. You must epoxy-cement a ¼-inch diameter extension of some kind to the capacitor's shaft *after* the capacitor is secured to the board; not before, because the mounting nut will not slip over a ¼-inch shaft.

If you use the capacitor from the kit source in the Parts List, you will find it is supplied with a special hollow shaft extension. To attach the extension, first secure the capacitor to the printed-circuit board, and then position the board in a vise so the tuning shaft sticks straight up. Cut about ¼-inch from a round toothpick, put a single drop of epoxy adhesive into the hole in the capacitor's shaft, and then place the toothpick section in the hole. About half of the toothpick will stick up above the stub shaft. Carefully place one or two drops of epoxy adhesive around the toothpick and then place the plastic shaft extension over the toothpick, centering the shaft on the stub. Let it set overnight. Be extra careful to use less rather than more epoxy. If it runs down the shaft it will make the variable into a *fixed* capacitor.

Next, install all components except coils L1/L2. The tab protruding from FET Q1's case should point at the nearest edge of the printed-circuit board. The flat side of transistor Q2 should face PEAKING capacitor C1.

Wind your own

Coils L1/L2 are partially homebrew. The main part, L1, is a J.W. Miller #6300 540-1700-kHz adjustable antenna coil. Coil L2, the input *link*, is made from 12 closewound turns of plastic insulated #24 or #26 wire that is cemented in place with *white glue*, or GE's Radio/TV cement. Do not use #20 or #22 hookup wire. #24 or #26 wire can be stripped from a length of flat ribbon cable, such as the kind sold by Radio Shack and computer stores.

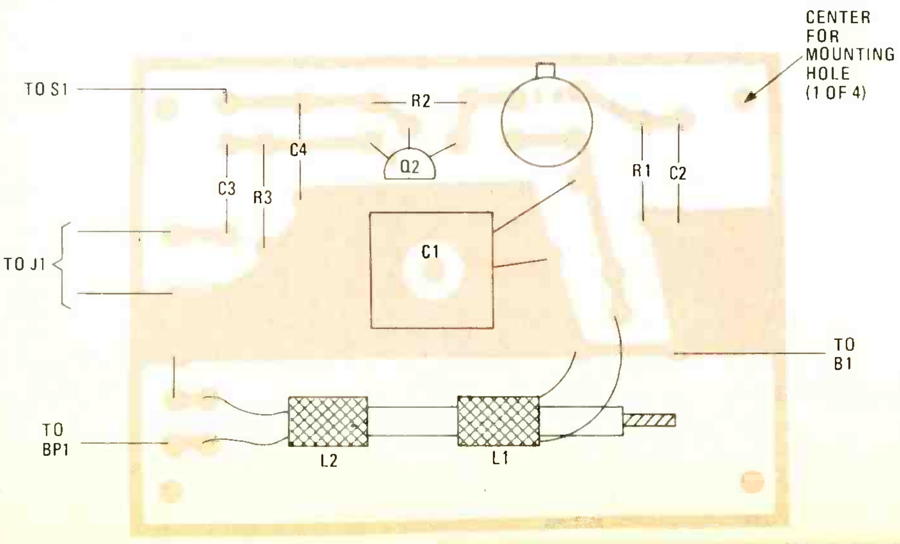
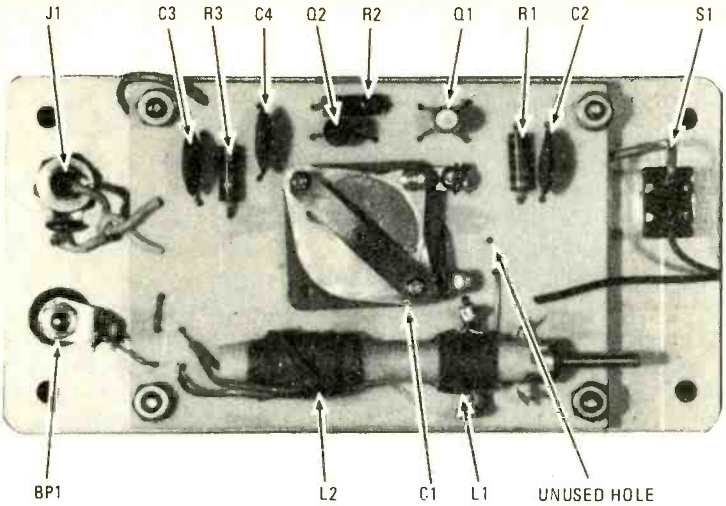


FIG. 3—THE DIAGRAM shows the location of parts mounted on the printed-circuit board. The foil pattern is shown in an X-ray view because the foil is on the underside of the board. Construction neatness will pay off with a project that functions the first time its turned on.



THE COMPLETED printed-circuit board is ready for installation in your choice of cabinet. To simplify the alignment preset L1/L2's tuning slug so it protrudes ½-inch from the cap.

Using about 12 inches of wire, starting about ⅛-inch from the top of L1's winding, wind 12 tight turns, then bring the two ends of the wire together over the approximate center of the coil (it's not critical), twist them twice to hold the coil together, and then apply the cement. Allow the cement to dry overnight and then cut L2's wires to 1¼ to 1½ inches. Strip ¼-inch of insulation from the ends.

Run out L1/L2's slug so the adjusting screw end is exactly ½-inch from the top of the cap. Place a moderately large blob of RTV silicon rubber adhesive directly on L1/L2, position the coil over the printed-circuit board as shown in the photos, and then push the coil against the board, squishing the cement between the coil and the board. Allow the cement to set overnight.

Connect L1 and L2 to the printed-circuit foils. The wires from L2—the coil you wound—connect through the holes near one edge of the board. Wire the terminals with L1's connections—the original winding—through the holes in the board located near PEAKING capacitor C1. Pass the wire from L1's terminal nearest the adjacent edge of the board under the coil form. You should wind up with one unused hole near L1/L2 and C1: That hole is for the *bulk* capacitor we'll cover soon.

If you are going to use a wire antenna, connect a jumper between one L2 hole wire and the nearest ground hole in the printed-circuit board. If you want an external antenna ground, or have both L2 connections above ground, do not use the jumper. Instead, provide an extra binding post on the cabinet and connect it to the free L2 hole.

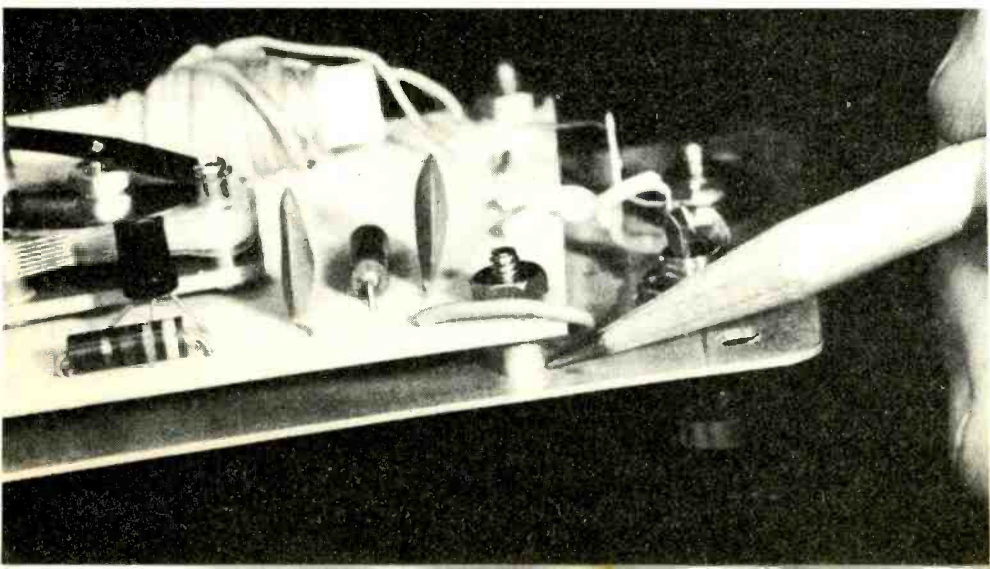
That completes the Broadcast Booster printed-circuit assembly. If you have used one of the 270-pF polyvaricons which were sold in electronic hobbyist stores, install a 100-pF, 100-WVDC silver-mica capacitor across C1. Place one lead of the 100-pF capacitor in the empty hole near C1 and L1/L2, and connect the free capacitor lead to the nearest C1 solder lug, the one connected to the printed-circuit ground foil, the C1 lug nearest L1/L2.

Install the assembly in the cabinet of your choice and connect ANTENNA binding post BP1, output jack J1, ON/OFF switch S1 and the battery connector. If you use a metal panel, make certain that you use standoffs between the board and the panel at each mounting screw to prevent the foils from shorting to the panel. A $\frac{3}{16}$-inch standoff, or stack of washers, is adequate. If the standoffs are too long, it will be difficult to install a knob on C1 because not enough shaft will be sticking through the panel.

PEAKING capacitor's C1's knob might present the only problem you'll have. The shaft extension provided with C1 is exactly ¼-inch. Older American-manufactured knobs fit the ¼-inch shaft. The experimenter-grade knobs presently manufactured in America, and offshore, are a universal size to fit *metricized* shaft dimensions; sort of a one-size-fits-all knob. Like anything that *fits all*, they really fit nothing well, and they certainly don't fit a true ¼-inch shaft. Either you will have to use an older true-size knob; or you could carefully ream a new knob to size with a ¼-inch drill bit.

Alignment

Install the battery, connect a few feet of wire to antenna connection BP1, and connect J1 through coaxial cable to your receiver's input terminals. Adjust PEAKING capacitor C1 full counterclockwise (maximum capacity). Turn the Booster on. Now tune the receiver to an extremely weak signal at the low end of the broadcast band, as close as possible to 540 or 550 kHz. If the tuned signal is closer to 600 kHz, adjust C1's shaft very slightly clockwise—just a *smidgen*.



SHOULD YOU USE a metal front-panel, make certain to use spacers between the printed-circuit board and the front panel to avoid accidental shorts. Additionally, be sure to clip the component leads close to the printed-circuit board.

MODIFYING THE TUNING CAPACITOR

TO INSTALL a shaft extension on the tuning capacitor, mount the capacitor on the printed-circuit board, put a drop of epoxy cement in the shaft, and place a ¼-section of round toothpick in the hole. The toothpick will center the extension shaft.

PLACE TWO SMALL DROPS of epoxy around the toothpick, mash the shaft extension into the epoxy with fingertip pressure, then center the shaft extension on the stub shaft and allow the cement to set.

Very carefully slip the cap securing L1/L2's tuning slug off the form and then slowly move the slug in and out of the coil. At some point you will hear the signal suddenly peak. (If it sounds as if the Booster is breaking into oscillation, just forget about the oscillation for now.) With the slug in the position that peaked the signal, measure distance from the top of the coil form itself (not the cap) to the tip of the slug adjusting screw. Note the measurement. (If C1 is a 356-pF unit the measurement should be about ½-inch.)

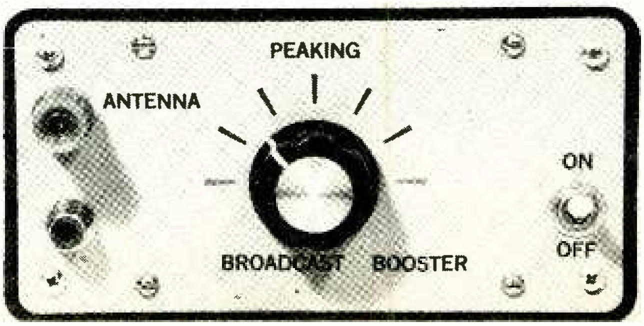
Push the cap back into place on the coil form and adjust the slug so that the tip of the screw protrudes from the cap the measured value. Then carefully back the slug out a few turns (counterclockwise) until the signal peaks. That finishes the alignment. Check the adjustment by tuning a station on the top of the dial between 1500 and 1700-kHz and then peaking the station with the Booster. If you seem to be just short of peaking the signal before C1 locks at its extreme setting you have probably not done the alignment correctly. (Note: It might not be possible to peak a signal above 1550-kHz if C1 is a 270-pF polyvaricon capacitor.)

It's not necessary to calibrate the panel for C1; a *ballpark* adjustment is close enough to start. If you're going to DX the low end of the band set C1 full counterclockwise to maximum capacity. For the middle of the BC band—about 1000 kHz—set C1 to half mesh. Set C1 to full clockwise—minimum capacity—for DXing the top of the band.

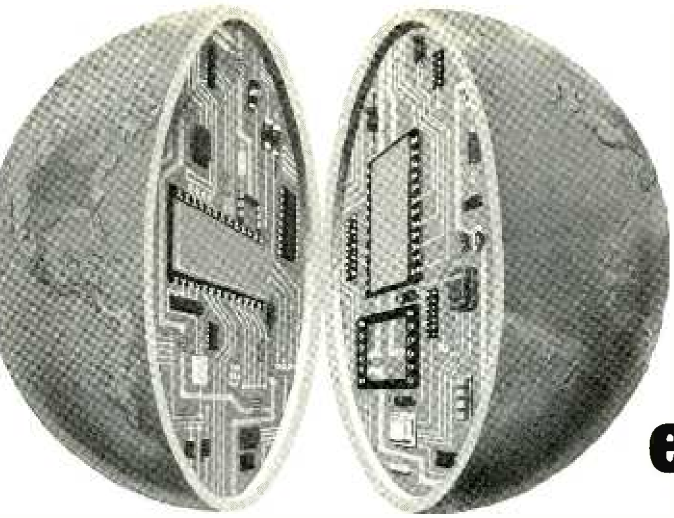
The Finishing Touch

The gain of the Booster is quite high and the circuit will sometimes break into oscillation if the antenna lead is too close to the input connections of the associated receiver. If that happens, adjust PEAKING capacitor C1 so that the signal is peaked as the Booster is tuned from a low frequency to a higher frequency. Usually, you will hit the peak before the adjustment that causes instability. If not, just back off the peak (toward a lower frequency) until the oscillation stops.

Keep in mind that the Booster will only boost a *weak* signal; if the signal is already sufficiently strong to produce a substantial S-meter reading, the Booster will not increase the volume from the speaker because the receiver's AGC (automatic gain control) will compensate for the extra gain of the Booster. At most, the S-meter will simply indicate a stronger signal. Also, the Booster cannot create a signal that doesn't exist. Sometimes, it will produce a signal where not even a trace could be heard; other times, it will produce nothing but extra noise because, the desired signal simply isn't there. One way to find out if there's a signal in the noise level is to turn the receiver's BFO on. If there's any signal at all in the noise, the BFO will produce a faint whistle or tone, even if you can't hear a signal without the BFO. The Booster might make it possible to receive the signal. But if the BFO can't produce a tone there simply is no signal to be received. **SP**



THE ONLY PARTS on the complete project that mount on the front-panel are ANTENNA binding post BP1, output jack J1, and ON/OFF switch J1. Note that the power lead from the switch S1 is routed under the printed-circuit board.



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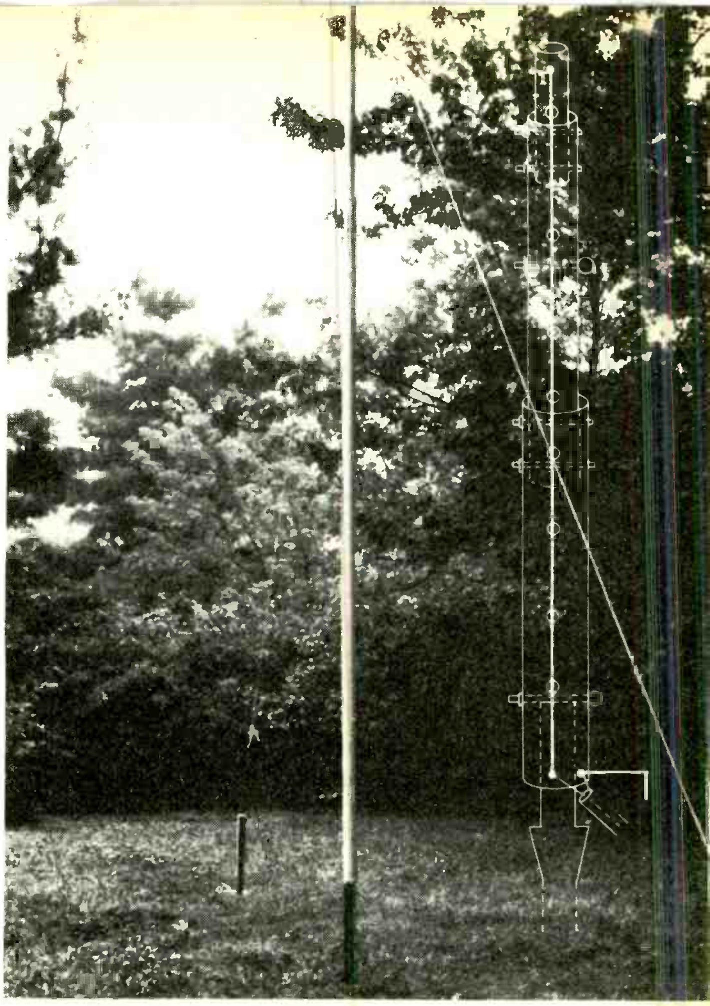
PVC Piping Puts Up SWL Antennas



ED NOLL

You alone can erect an SW skyhook like the pros do!

☐PVC PIPING LENDS ITSELF TO THE CONSTRUCTION OF SIMple, low-cost shortwave-listening (SWL) antennas. A PVC antenna mast, 20 feet or more, can be constructed at ground level, lifted up by a single person, and set in position over a metal fence post that has been previously driven into the ground. Such an antenna mast is light in weight, and uses a simple support structure, hardware, and guying (when required). Few, if any, insulators are required and no insulated base is necessary in the construction of a vertical antenna. PVC piping can be used to build ham antennas as well as antennas for other communications services.

Vertical Antenna Construction

A simple PVC-supported wire vertical antenna is shown in Fig. 1. The PVC mast consists of two 10-foot lengths and a shorter 3½-foot length. The choice of inner diameters of 2, 1½, and 1 inches permits easy telescoping of the PVC piping. The middle mast section is telescoped two feet into the bottom section and held in position by two bolts. (See Fig. 1.) A 3½-foot length of the top section is telescoped 1½-feet into the middle section and bolted fast. The overall length of the antenna mast is 20 feet.

A resting bolt is placed in position two feet from the bottom of the lower section. (See Fig. 1.) After the antenna is built. it is lifted onto the metal fence post, and it will drop over the post the length of two feet.That technique will provide ample support for the very light-weight mast. If the fence post is driven straight into the gound, the mast is just about self-supporting. In a practical situation an eye-ring bolt can be inserted about halfway up the middle section. Two or three nylon guy ropes permit you to set a true vertical position. If you prefer, you can eliminate the resting bolt and let the mast rest on ground. Better still, rest the mast on bricks that are sloped to let rain drip away from the mounting post.

Two holes are drilled at the very bottom of the lower section of the mast for the insertion of a pair of nut/bolt terminals. (See Fig. 1.) Be sure that those terminals do not touch the fence post. The end of the 18-guage, solid, insulated-wire vertical antenna is connected to one terminal using a solder ring or solder lug.Its overall vertical length of 19½ feet corresponds to an approximate quarter-wavelength on the 25-meter band. The antenna wire is fed through a series of eye rings that have been set in the PVC mast. Drill a small starter hole and screw in the eyes. The antenna wire is inserted through the top screw-eye and laced firmly to insure a taut antenna. You may want to wrap the end of the copper wire around itself and use some solder to lock the mechanical connection.

The inner conductor of the coaxial antenna feedline connects to the antenna terminal. (See Fig. 1.) Spade lugs or rings can be used to make that connection. The copper braid of the coaxial feedline connects to the remaining ground terminal. A ground rod driven into the soil close to the antenna base, or a set of three 20-foot radials, are connected to that ground terminal. The three radials are enough to produce an effective ground plane; however, for those who like to over-build, four or more wouldn't hurt. The radials are to be run straight out from the mast equally spaced apart, and stretched, at ground level. If desired, the radials may be buried approximately two inches beneath the surface.

The vertical antenna has been a favorite of DX'ers for long-distance, low-wave-angle reception. It occupies very little space and performs well. Good results are obtained on the 11- through 49-meter bands. Acceptable results are obtained on the lower frequency band considering the short length of the antenna wire.

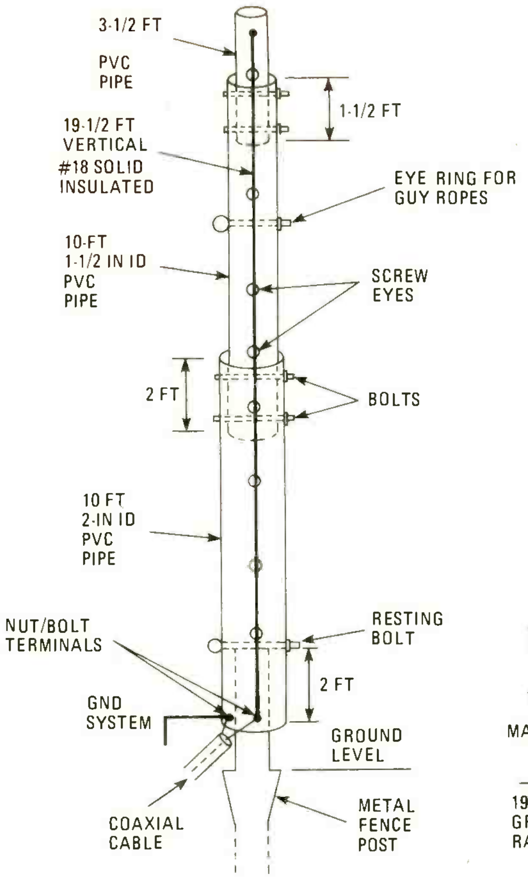
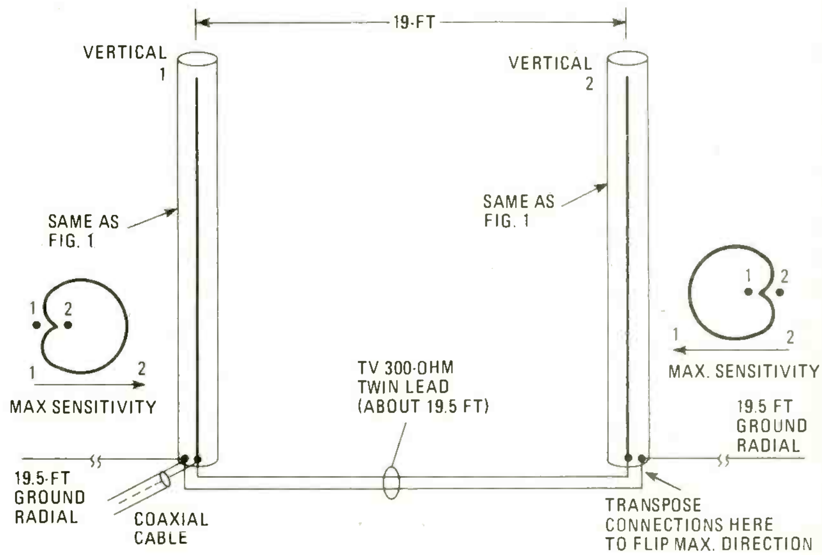


FIG. 1—CONSTRUCTION DETAILS for the simple vertical antenna described in this article. PVC piping is obtainable at your local plumbing-supply house in 10-foot lengths—don't ask them to cut it! The piping yields quickly to a hacksaw or even a circular saw. The metal fence post is a standard Sears item.

FIG. 2—DIRECTIONAL SECTION for improved reception is made possible by the ganging of two vertical antennas at a prescribed distance and interconnecting them. A cardioid reception pattern permits the suppressing of powerful signals from one direction in overpowering others of the same frequency coming from the remaining three corners of the compass.

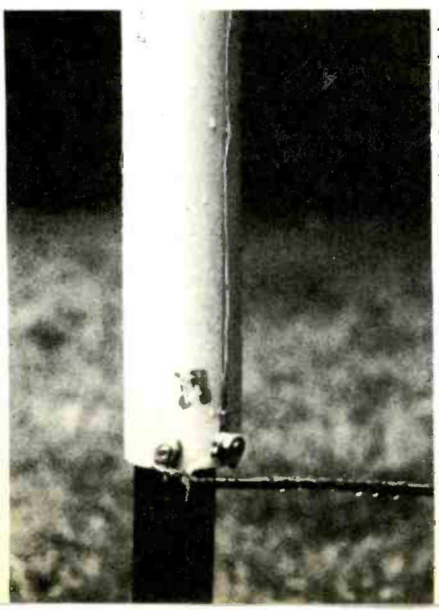


A Simple Vertical Beam

Two or more identical vertical antennas can be erected in various end-fire and broadside configurations to obtain higher sensitivity and less pickup in other directions. A two-vertical antenna combination is shown in Fig. 2. The two vertical antennas in our vertical-beam system were identical to that of Fig. 1. They were spaced a quarter wavelength apart on the 25-meter band. An approximate ¼-wavelength segment of flat 300-ohm TV line interconnects the two verticals. That corresponds to approximately 90° lagging vertical 1. We will see how that affects the beam antenna's reception.

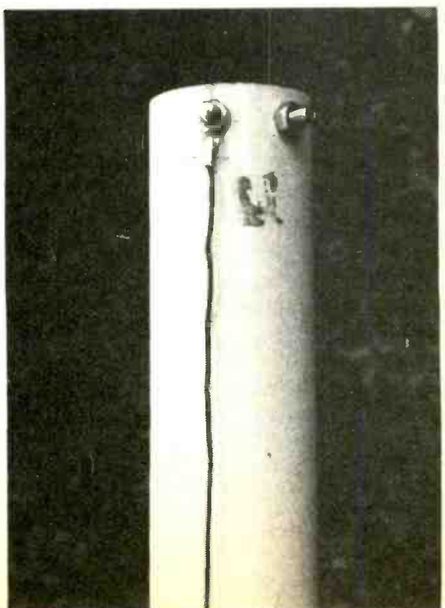
That method of antenna interconnection establishes a cardioid pattern, as shown in Fig. 2. Maximum sensitivity is in line with the verticals in a direction from vertical 1 toward vertical 2. It should be noted that the cardioid pattern indicates a rather broad sensitivity in one direction. However, the sensitivity is poor in the opposite direction and the antenna is said to have a high front-to-back ratio. That type of pattern is advantageous when there is a possibility of interference from a strong local signal that comes in the back direction. The pattern does two things: It increases sensitivity to the desired signal and reduces sensitivity to the undesired signal. That is better in terms of overall performance than just increasing the antenna gain.

Antenna height is again 19.5 feet as in Fig. 1. There are also two 19.5-foot ground radials. They are laid down along the same line as the in-line between the two verticals; however, they extend away from the two verticals as shown. Those radials can be buried approximately two inches beneath the surface.



THE VERTICAL ANTENNA sits atop its fence-post support. Two terminals made from common machine screws are used to connect the antenna to the coaxial feeder line. Place a piece of scrap PVC pipe material behind the terminals inside the pipe to avoid accidental shorting to the fence post. Epoxy the material in place. The small beads on the coax are raindrops.

AT THE TOP of the mast, the vertical antenna copper wire is terminated in a solder lug and bolted to the mast. If you wish, you could omit that hardware and epoxy the copper wire to the mast. Extra bolt at top of mast is used to secure guide wire should one be needed.



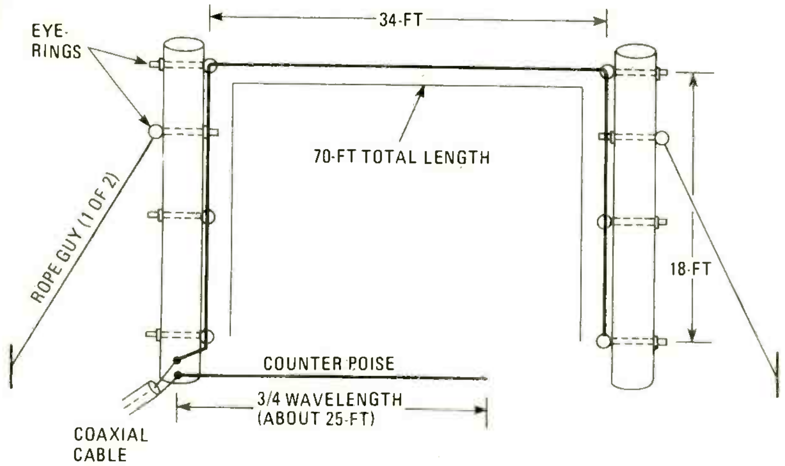


FIG. 3—TWO VERTICAL ANTENNAS may be used to erect a horizontal long-wire antenna to extend reception efficiently to the longer shortwave bands. The light weight of the antenna system permits the operator to erect trial antennas with minimum effort.

The directional sensitivity pattern of the two verticals can be flipped over 180° simply by transposing (reversing) the two 300-ohm line connections at the base of vertical antenna 2. That sets up a 270° phase lag; it is the same as a 90° lead. Therefore, the maximum sensitivity direction is from vertical 2 toward vertical 1. Changeover can be done very conveniently because the terminals are at ground level. Should you plan to do that frequently, install a non-polarized plug and jack at the base of antenna 2. Color code the plug so that you will know which direction the antenna is beamed when you make the terminal switch.

The antenna of Fig. 2 has good directional characteristics on bands 16, 19, 25, and 31 meters. Acceptable performance was obtained on other bands, albeit with little directional characteristics.

The two end-fire, beam antenna system illustrated in Fig. 2 was erected in southeastern Pennsylvania. In that location, Spain and Australia come within about 15° of 180° complementary directions. Consequently, it is a simple matter to make the necessary changeover to favor one or the other directions. There are probably a number of vertical beam configurations you would like to check out. The PVC mast construction is an easy way to do it.

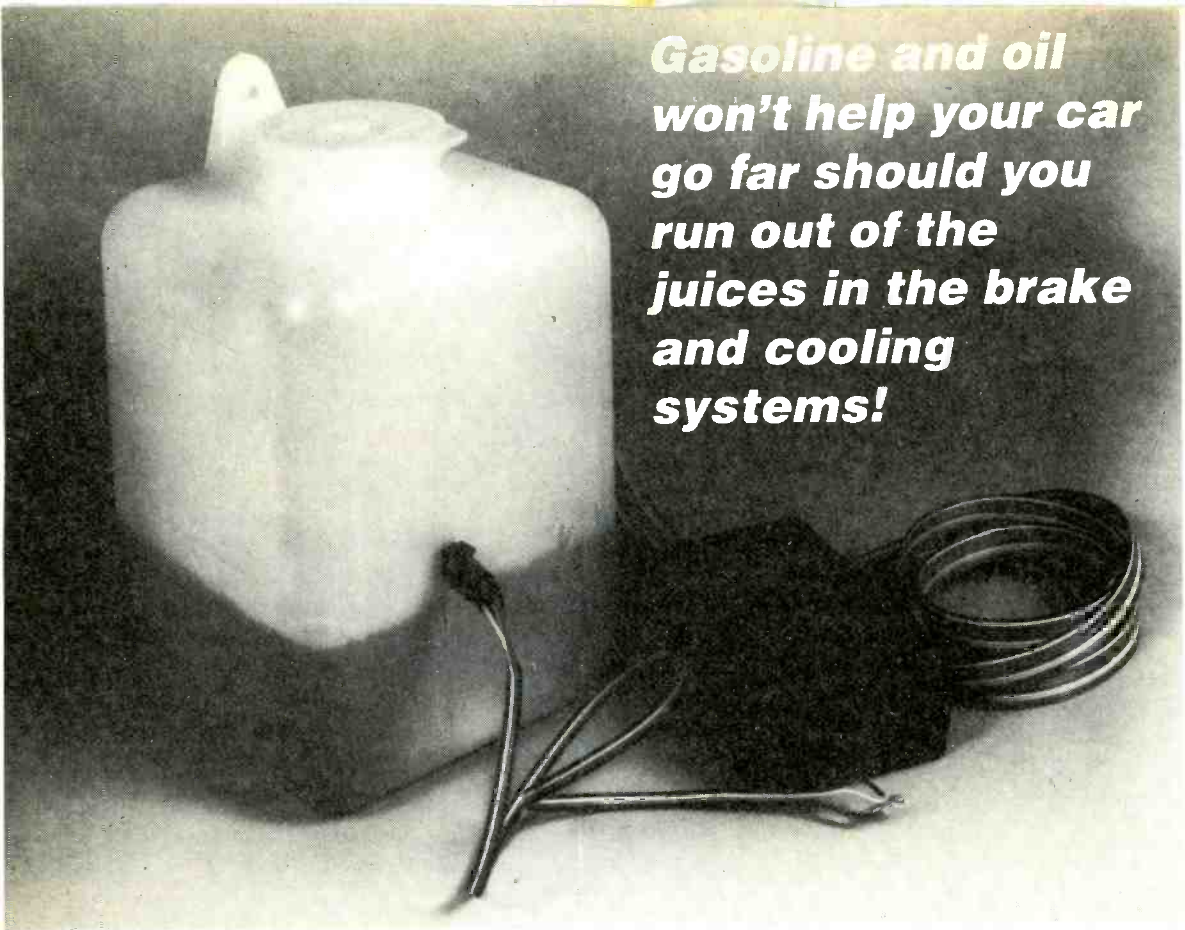
Long-Wire Applications

The PVC mast can be used also to construct horizontal and other antenna types in which the antenna itself is not strictly a vertical type. The example of Fig. 3 shows how a long-wire antenna can be erected to extend coverage into the lower-frequency shortwave bands. In that example, the antenna wire is fed through the mast's eye-rings and then stretched out toward a second PVC mast. Antenna wire is fed down the eye-rings of the second mast and fastened tightly at the bottom eye-ring. A typical overall length might be 70 feet, which corresponds to a quarter-wavelength on 90-meter band. The ground is in the form of a short counterpoise that extends between the two masts about ¾ of the total distance. It can be elevated or buried.

In the test antenna that was erected, two PVC masts are telescoped together for a height of 18½ feet. The effective antenna wire vertical rise was about 18 feet on each mast. Consequently, the horizontal span of the antenna wire was about 34 feet, obtaining an overall length of 70 feet. Thus a rather long antenna can be contained in a short space. Other length combinations can be chosen to meet your available mounting space. The overall simplicity is a favorable attribute, because you do not have to wrestle with metal masts and their added erection complications. When using insulated, wire you do not have to hassle with insulators and annoying bare-wire curl.

PVC masts can be built easily. They can be moved about readily, simply by moving the supporting metal fence posts. What an excellent time- and labor-saving means of antenna experimentation! **SP**

HERE IS the beam antenna diagrammed in Fig. 2. The author put this job up in two hours' time with the usual coffee break. Guys are inexpensive nylon line available at hardware stores. Piping can be obtained in black color should you not want to advertise the antenna's presence.



Albin
Hastbacka

Liquid Level Sensor

DURING THE PAST NEW ENGLAND WINTER, I EXPERIENCED radiator overheating on our family's two cars, loss of brake fluid in the first car, and a slow dripping of power-steering fluid in the second car. After those events, two of which required emergency roadside service, I decided that it would be extremely useful to have a gadget installed in my cars that would provide a visual indication as to the fluid levels in the windshield-washer bottle, radiator-overflow bottle, brake master-cylinder reservoir and the power-steering reservoir. Commercially available devices used to measure windshield washer fluid and coolant in the radiator overflow bottle depended upon penetrating the respective bottles with electrodes. I dismissed that type of device because of the probable leaks that would occur at the site where the electrode entered the bottles.

For measuring brake-fluid level in a master cylinder, I found that many of the newer Japanese cars were coming equipped with a float-type switch. That type of switch was unique to the shape and/or size of the bottle, so therefore, it would not be applicable for use in other types of cars.

I found nothing to measure power-steering fluid level.

During a visit to a new car showroom, I noted with great interest that in many new cars, the containers for holding the windshield-washer fluid, coolant overflow, brake fluid, and power-steering fluid were made of a translucent material. The purpose for using those polyethylene bottles was to provide the ability to check those fluid levels visually whenever the hood is opened. It was at that time, that I decided it should be possible to measure the fluid levels by connecting an optoelectronic sensor to the outside of the fluid bottle.

In researching how I might be able to attach a small sensor to a polyethylene bottle, I found that all of the "super glues" and newer adhesives were guaranteed to work on all plastics—*except* for polyethylene and polypropylene. The basic problem is that polyethylene has a very wax-like surface and very few adhesives will stick to it—in fact, polyethylene is used as a mold in casting certain types of plastics because of its release properties. After considerable experimentation, I found that by cleaning polyethylene with alcohol, and sanding in one direction with a medium sandpaper, I was able to cement small optoelectronic sensors reliably onto polyethylene bottles and have the bond last for a long time (more than 24 months to date within an engine compartment with no bond failure).

How It Works

The basic technique for sensing a fluid level in a translucent bottle is shown in Fig. 1. The drawing shows an infrared-emitting diode and a phototransistor mounted in a plastic housing which is attached to the wall of a polyethylene bottle.

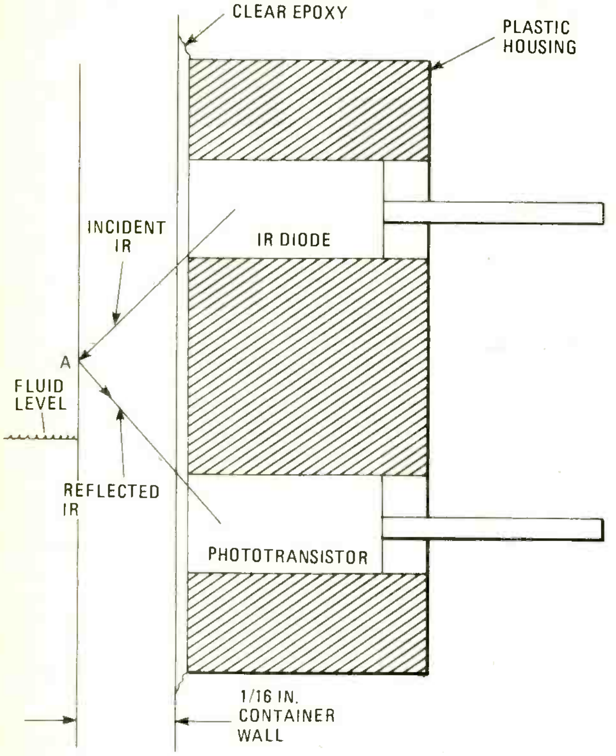
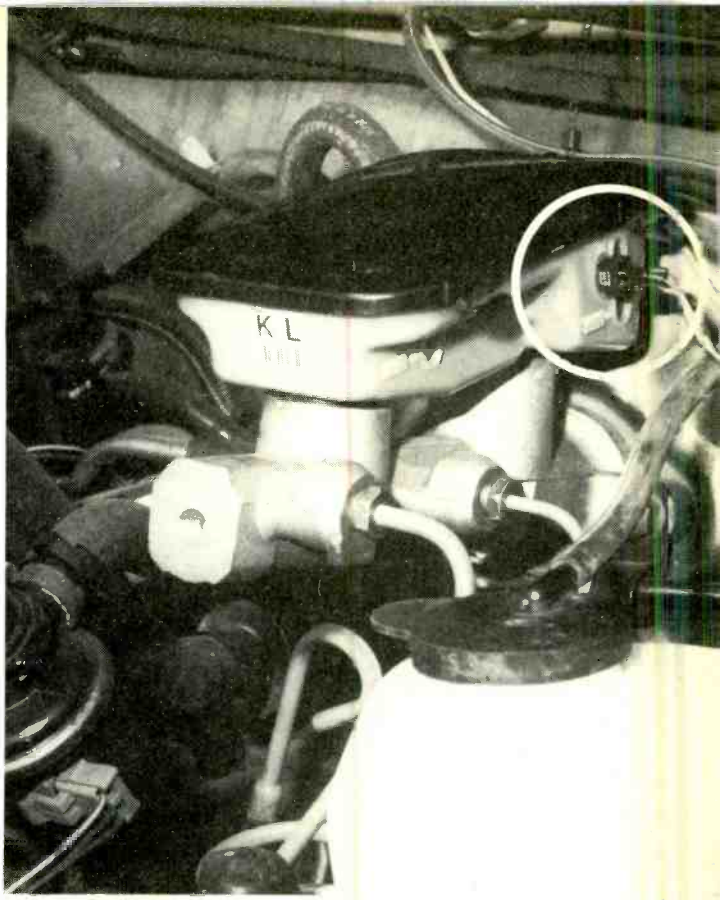


FIG. 1—THE OPTO-SENSOR consists of an infrared diode and phototransistor mounted in a plastic housing. Reflection increases when the container's fluid level drops below point A.

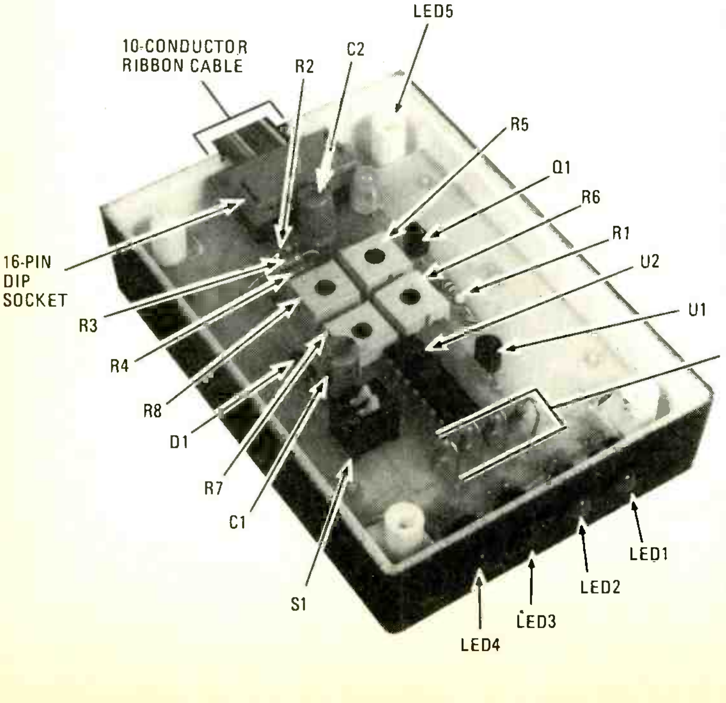


THE PLASTIC CONTAINERS for the master brake cylinder (center) and the window-washer fluid (lower right) were fitted with sensors (circle). Steering fluid container is not shown.

The diode is positioned so that infrared rays strike the inside surface of the polyethylene wall at an angle of approximately 45° at a position where the reflected rays are directed to the phototransistor. If there is no fluid in the front of location A in Fig. 1, a considerable amount of infrared (IR) energy is reflected because of an optical property, known as total internal reflection. If there is a fluid in front of position A, total internal reflection does not occur at that position and a reduced amount of IR energy is reflected at the phototransistor. It is that difference in reflected infrared energy that is used to sense the presence or absence of a fluid in the sensor.

If the container wall shown in Fig. 1 were transparent, the ratio of reflected energy with no fluid present to reflected energy with fluid present is typically 25 to 1. With a translucent wall, the corresponding reflected-energy ratio is typically 2 to 1 to 4 to 1. The difference is due to the fact that the translucent polyethylene wall diffuses the incoming IR energy, which provides an alternate light path that illuminates the phototransistor independent of the absence, or presence of, fluid in front of the sensor.

The sensor basically consists of an infrared-emitting diode and a phototransistor. The distance between the diode and the phototransistor must be such as to provide an adequate ratio between the situation where there is no fluid in front of the sensor to the situation where there is fluid in front of the sensor. For most of the polyethylene bottles which I have come across in automotive use, the wall thickness is approximately 1/16-in. For that wall thickness, the ideal spacing between the diode and the phototransistor is 1/8-in. Instead of manufacturing a custom sensor-source device for that application, I have found that using a standard device like the Optron OPB 711 provides adequate on-off ratio even though the source-sensor spacing is not optimal.



THE ELECTRONICS for the Liquid Level Sensor is housed in a small plastic box and mounted near the bottom of the dashboard, or on the steering column, in the car so that the surface that mounts the four LED's is visible to the driver when he is driving. Red LED's indicate low brake and steering fluids and yellow LED's, window-washer and radiator-overflow fluids.

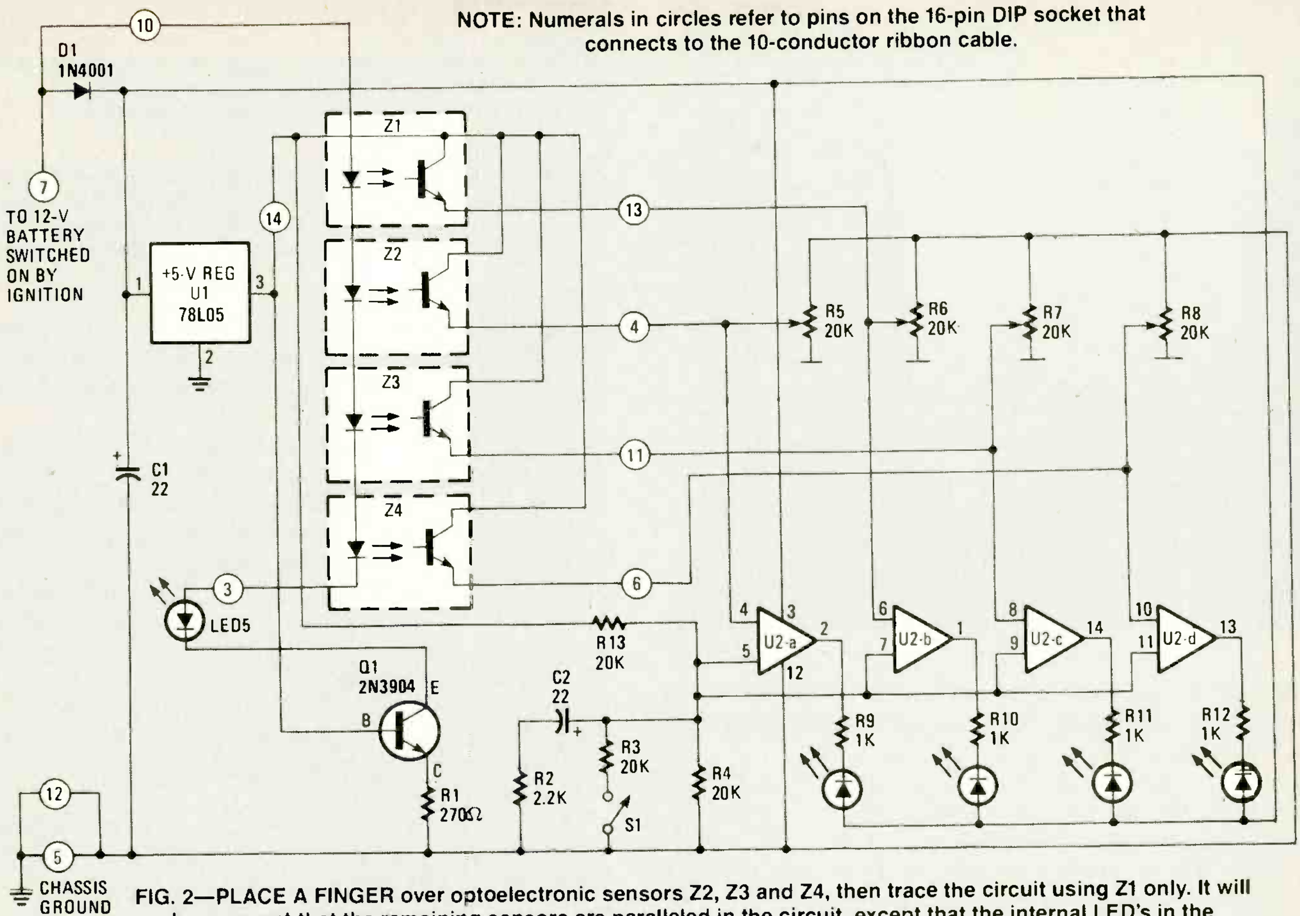


FIG. 2—PLACE A FINGER over optoelectronic sensors Z2, Z3 and Z4, then trace the circuit using Z1 only. It will be apparent that the remaining sensors are paralleled in the circuit, except that the internal LED's in the sensors are hooked up in series. LED5 is used only when one or two sensors are wired in the unit you build.

PARTS LIST FOR LIQUID LEVEL SENSOR

SEMICONDUCTORS

D1—1N4001 rectifying diode
LED1-LED4—Light-emitting diodes (2 amber, 2 red)
LED5—Light-emitting diode (Used only if 1 or 2 Optron OPB 711's are used. When three or four OPB 711's are used, substitute a jumper wire for that LED.)
Q1—2N3904 NPN transistor
U1—78L05 +5-volt regulator
U2—LM339 quad comparator integrated circuit
Z1-Z4—Optron OPB711 Phototransistor/LED reflective array

RESISTORS

(All fixed resistors are ¼-watt, 5%)
R1—270-ohm
R2—2200-ohm
R3, R4, R13—20,000-ohm
R5-R8—20,000-ohm, single-turn, ½-watt potentiometer
R9-R12—1000-ohm

ADDITIONAL PARTS AND MATERIALS

C1, C2—22-μF, 25-WVDC capacitor
S1—2 (or 4) pin DIP switch (SPDT)
Printed-circuit materials or pre-etched circuit-board (see below), Unibox enclosure, mounting hardware for LED's (Clip-T-134B), 16-pin DIP socket, 16-pin DIP connector, 10-conductor flat-ribbon cable (length suitable for automobile), hardware, epoxy (see text), solder, etc.

WHERE TO BUY

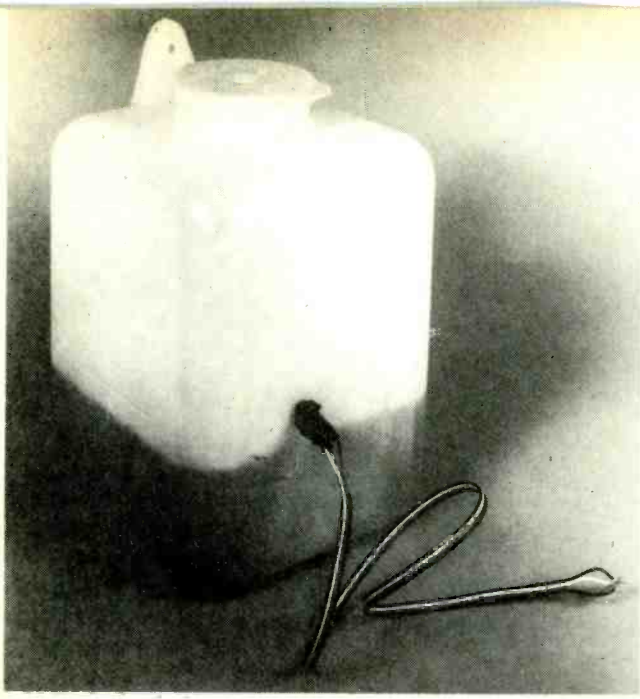
The following parts are available from Chatham Research, P.O. Box 334, Chelmsford, Mass. 01824:
PC Board at $5.50;
PC Board with two OPB 711's at $12.95;
PC Board with three OPB 711's at $16.50;
PC Board with four OPB 711's at $19.95;
Add $1.90 for shipping and handling ($3.00 for Canada) to the above prices. Mass. residents please add 5% sales tax.

The first few sensors which I built used photo-Darlington's rather than phototransistors, but I do not recommend photo Darlingtons, because of the wide variation in output current versus temperature. The combination of an infrared diode driven at a constant current and a phototransistor provides a sensor whose output is quite constant (±10%) over a wide variation in temperature (15° to 75° C).

Circuit Operation

The four IR diodes of the four liquid-level sensors, Z1-Z4, are wired in series to the collector of transistor Q1 as shown in the schematic diagram of Fig. 2. The base of Q1 is driven by the 5-volt output of a 78L05 voltage regulator, U1. That voltage is applied to the base of Q1, and the resistor R1 connected to the emitter of Q1 produces a current of approximately 15 milliamperes in the four IR diodes. Diode D1 is used to protect the circuit if the automobile battery voltage should inadvertently be applied with reversed polarity. (Inductive kickbacks from the starter motor are known to place large negative voltage spikes on the battery line.) Capacitor C1 filters out positive and negative voltage spikes from the automobile electrical system.

Each of the four sensor phototransistors (Z1-Z4) is connected to a variable resistor (R5-R8) to provide a voltage input to each of the four comparators within U2. Each phototransistor drives the inverting input of the respective com-



◀ **THE RADIATOR OVERFLOW BOTTLE, is shown here with a sensor glued to its side wall with clear epoxy. The color-coded ribbon cable takes the guesswork out of in-auto hookup.**

MASTER CYLINDERS usually have two fluid reservoirs, each of which requires a sensor. In the photo only one sensor is visible. Be sure to route the ribbon cable away from the exhaust manifold—the heat will melt the plastic insulation. ▶

parators of U2. The variable resistors allow for compensating phototransistor device differences and optical differences of the polyethylene bottles.

To adjust variable resistors R5 through R8, switch S1 is closed to set the non-inverting input of the four amplifiers within U2 to a voltage of 1.65 to 1.7 volts. Sequentially, each of the variable resistors is turned in a counterclockwise direction until the corresponding light-emitting diode (LED1-LED4) just turns on. The calibration procedure is done with fluid levels above the sensors. Switch S1 is now positioned from the calibrate position to the operate position. With switch S1 in the operate position, the series combination of R13 and R4 driven by the voltage regulator output provides a reference voltage of 2.5 volts to the non-inverting input of the four comparators in U2. The output of a comparator will be high (+5-volts) when a fluid is in front of the photoelectric sensor (Z1-Z4), because the output of the phototransistor will be approximately 1.65 volts. When the fluid level drops below a sensor, the corresponding phototransistor will drive the inverting input of the comparator to a voltage of three or more volts which is higher than the reference voltage of 2.5 volts. The output of the comparator will then be low (ground), illuminating the corresponding LED indicator showing that the fluid level is below the sensor.

In order to provide a simple GO-NO GO test feature, the combination of R2 and C2 (Fig. 2) is connected to the non-inverting inputs of the four comparators. When the automobile ignition switch is first turned on, the combination of R2 and C2 sets the initial reference voltage to approximately 0.5 volts. The four output LED's will turn on momentarily until the reference voltage rises above 1.65 volts. That simple test feature provides high confidence that the all the sensor circuits are operational.

A printed-circuit board foil pattern and its corresponding component placement diagram are shown in Figs. 3 and 4. All the components should be soldered directly to the board so that the various shakes, shocks, and vibrations associated with an automobile do not jar the components loose. The wiring between the printed-circuit board and the sensors under the hood should be #28 wire or larger so that sufficient drive current can be supplied to the series-wired infrared sources within the sensors.

The packaging of the Liquid Level Sensor printed-circuit board is accomplished by using a small (3.75-in. long x 2.65-in. deep x 1.50-in. wide) ABS molded enclosure. The prototype project used an Amerex Unibox 120 with four holes drilled in the front to provide viewing of the four output LED's. The Unibox has provisions for mounting the printed-circuit board in a horizontal position as shown in the photograph. To provide a convenient means of cabling between the circuit board and the sensors, a 10-conductor, flat-ribbon cable was connected to a sixteen-pin DIP connector and plugged into a 16-pin DIP socket mounted on the circuit board. The prototype unit was attached to the underside of the dashboard using a Velcro fastener.

If it is desired, the molded enclosure can be hidden behind the dash with the outputs remoted to the LED's mounted on the dashboard with appropriate mounting hardware.

Installation

The installation of the Liquid Level Sensor consists of mounting the enclosure and the sensors. The enclosure should be mounted on, under, or in the automobile dashboard so that it can be easily viewed by the driver. The printed-circuit board should always be mounted in an enclosure to prevent accidental damage or circuit shorting. The display LED's should be positioned on the dashboard to minimize being washed out by sunlight.

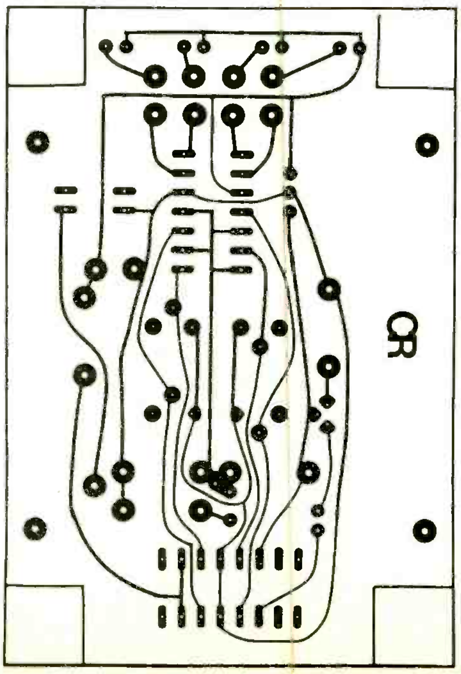
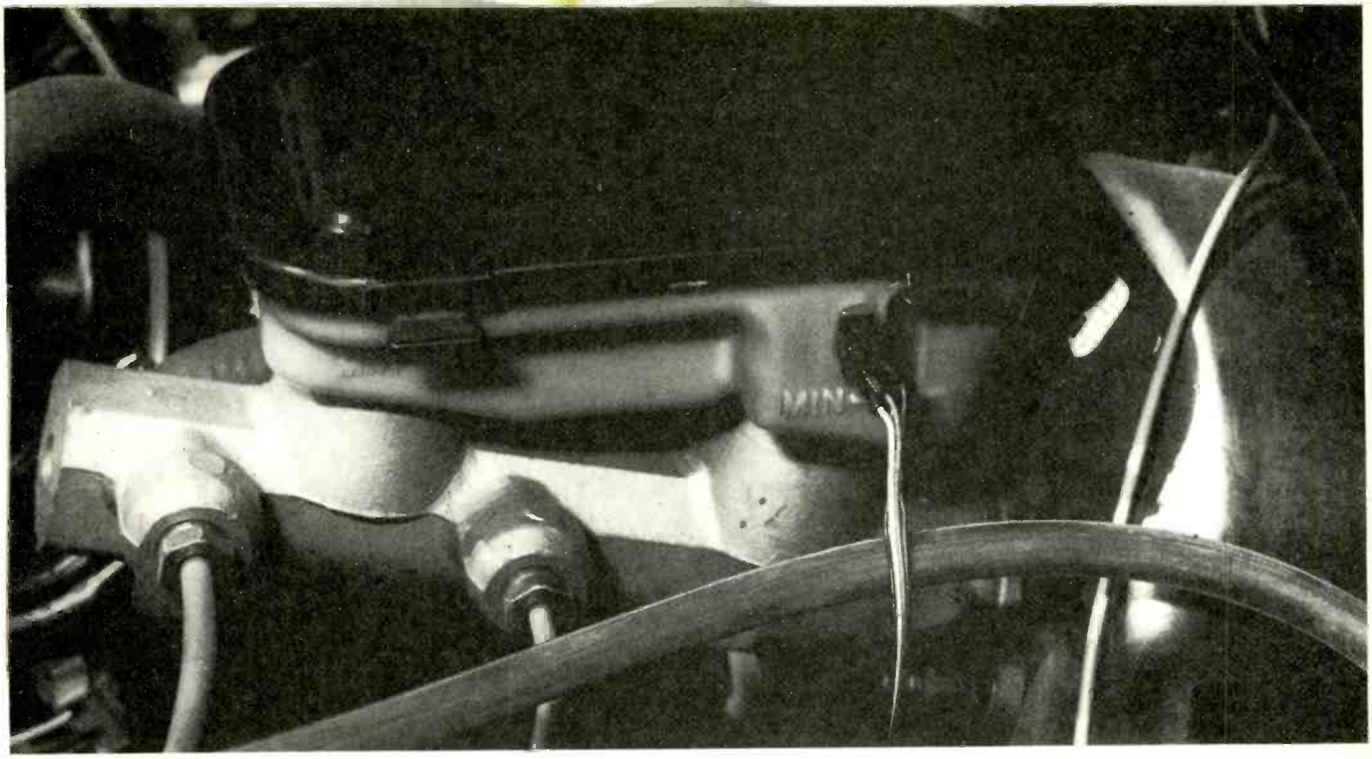


FIG. 3—HERE'S A FULL-SIZE foil pattern for the printed circuit board used to assemble the Liquid Level Sensor.



The sensors specified are Optron OPB 711's. A clear epoxy such as Devcon 5-Minute Epoxy should be used for cementing the sensors into place.

The wiring to the sensor should be soldered into place and the connection covered with RTV or shrink tubing to prevent moisture from collecting between leads.

The sensors should be placed on their respective fluid containers in such a way as to minimize ambient light from outside of the engine compartment. When the hood is open, the sensors will be exposed to ambient light which may result in displaying incorrect fluid-level conditions. However, when the hood is closed, the ambient light level within the engine compartment is usually very low, even on the brightest sunny days. The proper installation of the sensors requires that the sensors be exposed to a minimum of ambient light when the hood is closed so that false fluid level conditions are not displayed to the driver.

In order to attach a sensor on a polyethylene bottle, the following is recommended:

1. Select a location level on the fluid bottle on or just slightly above the fluid "safe" level for your car.

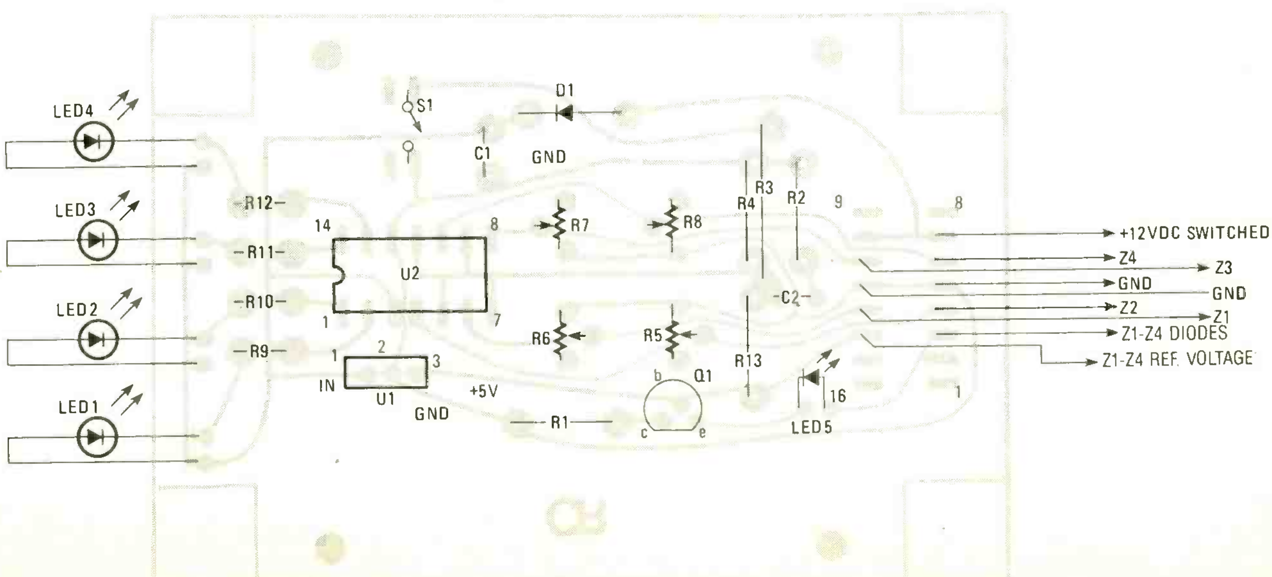
2. Thoroughly clean the selected area with alcohol or an Alcohol Prep Pad and allow the surface to dry.

3. Scour the selected surface with #120 sandpaper. Sand in one direction only. The tests to date have used 3M #120 sandpaper.

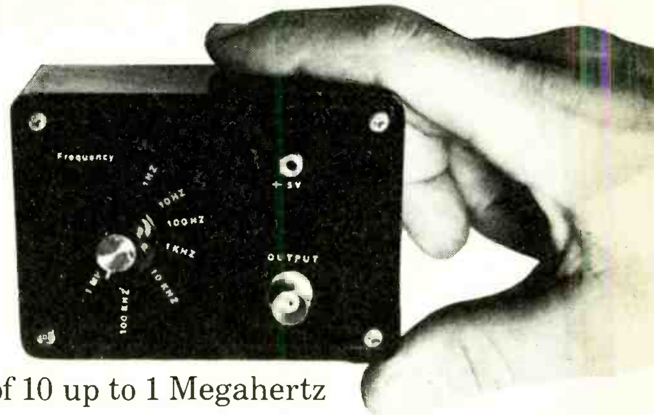
4. Apply a high-quality transparent epoxy resin such as Devcon 5-Minute Epoxy to the sensor and apply to the selected area.

5. Hold the sensor in place with a rubber band, or by hand, until the epoxy has set. Field tests to date with the specified epoxy indicate that it has adequate strength after 24 months operational use in an automobile. To be on the safe side, specified epoxy could be used to quickly tack the sensor in place, and then apply a higher-quality epoxy around the edges of the sensor to provide a better waterproof bond. **SP**

FIG. 4—WIRING DETAILS for the Liquid Level Sensor are shown here superimposed on top of an X-ray view of the printed-circuit board. The corner squares are to be notched out to fit the box specified in the article.



Crystal-Controlled Pulse Generator



You pick the frequency from 1 Hertz to any multiple of 10 up to 1 Megahertz

JAMES E. OSLISLO

RIGHT NOW I'M SURE YOU'RE SAYING, "OH NO, NOT ANother pulse generator! I already have half a dozen of those contraptions in my cellar." Well, so do I. But that doesn't mean you don't need another. Why should you build the Crystal-Controlled Pulse Generator? Well, for one reason, it's small, so you don't have to drag around something of a size and weight somewhere between a brick and a Buick. Another reason is that it's cheap and easy to build. Anyway, if you really need a reason, just use the same one you used when you built your sixteen-bit, microprocessor-controlled doorbell chimes. You know, the one you said might come in handy someday.

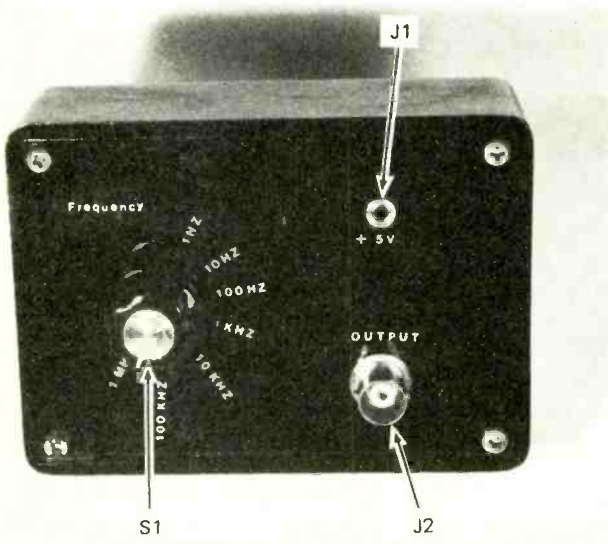
What can you use the Crystal-Controlled Pulse Generator for? Use it as the time base for a frequency counter or as a source of an accurate squarewave. Many timer projects need a one-Hertz timebase. The generator should be useful in digital circuit breadboarding, and, because of its small size, it may be incorporated into a final project design. The signal put out by the generator is compatible with both CMOS and TTL circuits. It is an ideal project for the beginning hobbyist because of its simplicity; assembly is not too difficult, and there are not that many things to check out if an error or two should creep into the project. So go ahead and build it; you can never have one too many pulse generators.

How It Works

The circuit functions of the Crystal-Controlled Pulse Generator can be divided into three main parts. The first part generates the high-frequency signal, the second part divides that signal into its component frequencies, and the last part buffers the desired frequency for outside use. Refer to the schematic diagram (Fig. 1) for the descriptions of those parts.

Resistors R1 and R2 combine with capacitors C1, C2 and C3 and crystal XTAL1 form a feedback network for NOR gate U1-a, forcing it to oscillate at a one-megaHertz rate. That frequency is cascaded from one counter section to the next, dividing it by a factor of ten each time. The counters used are CMOS 4518 integrated circuits (U2-U4) which include two divide-by-ten counters in each DIP chip.

The basic frequency and the six outputs are routed to rotary switch S1 which selects the desired frequency. The output from that switch is applied to the buffers formed by U1-c and U1-d, which are in parallel to give it a little extra "oomph". The output from those buffers is wired into jack J2, which



THE GENERATOR'S CIRCUIT ELEMENTS fit snugly inside a plastic case. Panel lettering gives project the pro's touch.

PARTS LIST FOR CRYSTAL-CONTROLLED PULSE GENERATOR

SEMICONDUCTORS

U1—4001A CMOS quad 2-input NOR gate integrated circuit
U2—U4—4518 CMOS dual synchronous divide-by-ten counter integrated circuit

RESISTORS

(All resistors are ¼-watt, 5% units)
R1—10-Megohm
R2—22,000 ohm

CAPACITORS

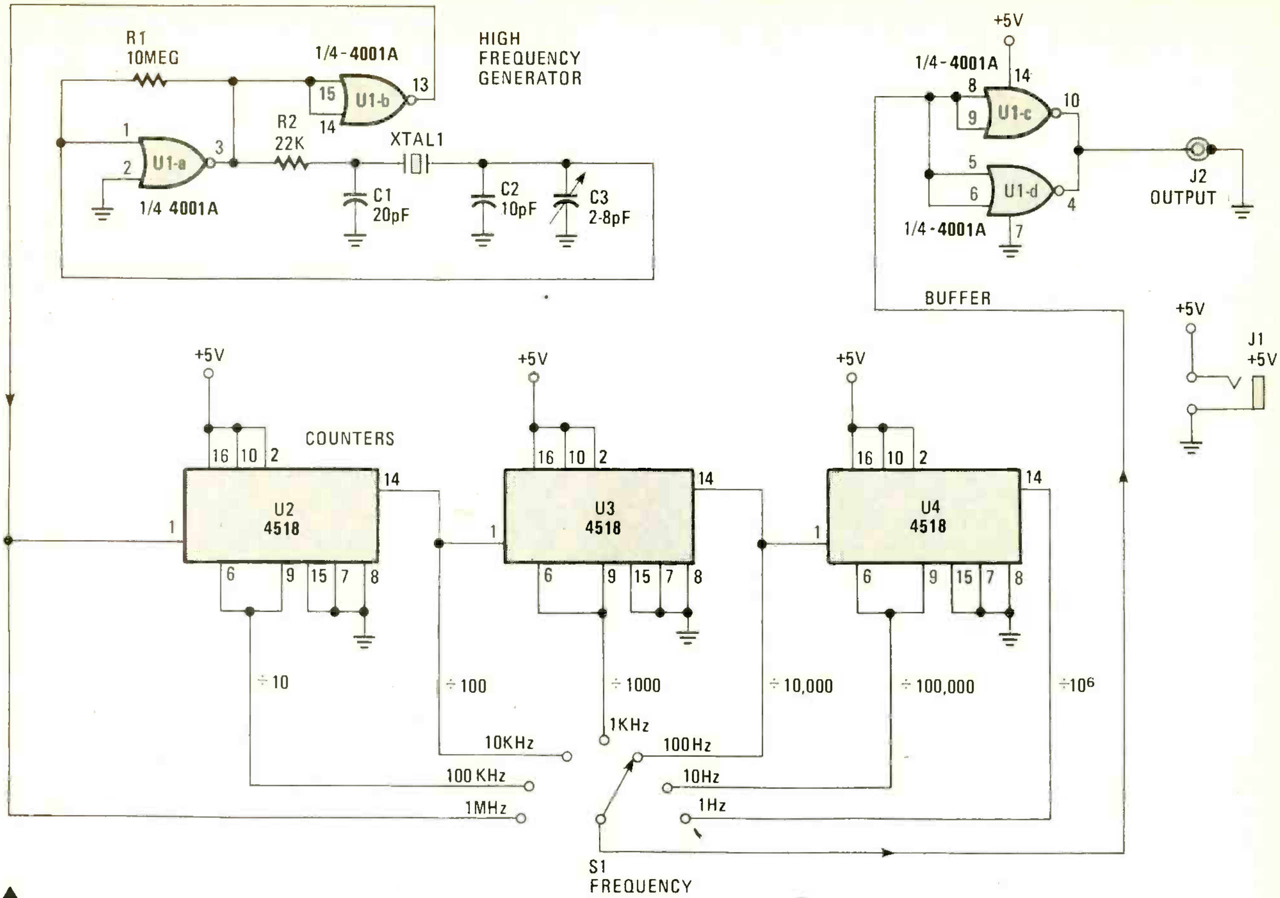
C1—20-pF, ceramic disc
C2—10-pF, ceramic disc
C3—2-8-pF trimmer

ADDITIONAL PARTS AND MATERIALS

J1—miniature phone jack
J2—1094 female BNC connector
S1—1-pole, 12-position rotary switch
XTAL1—1.0000-MHz crystal
5-VDC, 150-mA wall-plug power supply, 4- X 2⅞- X 1½-in. plastic case with plastic cover, printed-circuit board materials, enclosure, knob, etc.

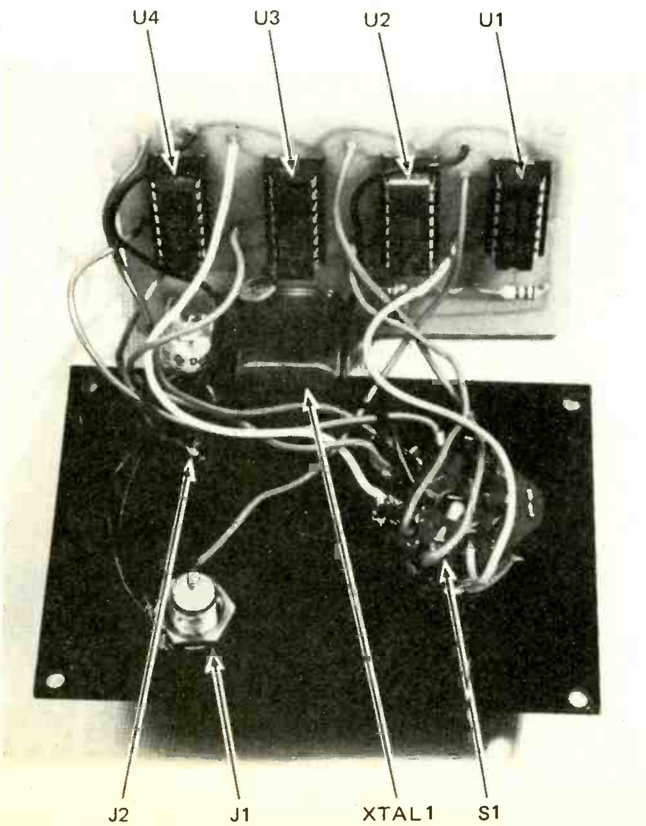
The following are available from Micro Mart Inc., 508 Central Ave., Westfield, NJ 07090; Tel: 201/654-6008:

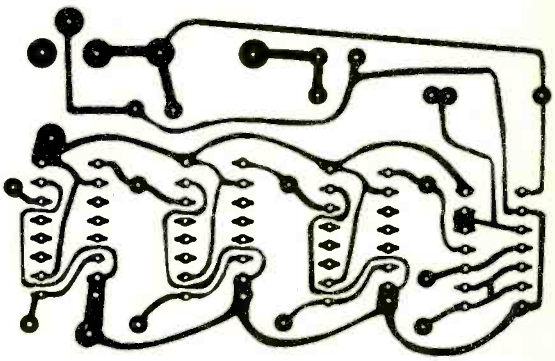
Etched and drilled printed-circuit board, $10.00.
Complete kit with power supply $39.95.
Add $2.00 for shipping and handling; New Jersey residents add 6% tax.



▲
FIG. 1—THE CRYSTAL-CONTROLLED Pulse Generator diagram is simple and can be followed without text instructions.

FIG. 2—SAME-SIZE CIRCUIT BOARD foil diagram is useful to ▶ those who have trouble with point-to-point wired projects.





allows the signal to be sent to the outside world. To increase fan-out of the buffers, it is desirable to use a 4001A device for U1 that sources more current then a standard 4001B.

Power is supplied to the Crystal-Controlled Pulse Generator by a basic five-volt DC, 150-mA, calculator wall-plug power supply through jack J1. The five-volt regulated supply enables the output to be used with both CMOS and TTL circuits. Should you be unable to obtain such a wall-plug power supply, then you could resort to a simple built-in 5.1-volt Zener diode regulator circuit. Any wall-plug power supply rated between 6- and 12-volts DC may be used.

Assembly instructions

The assembly of the Crystal-Controlled Pulse Generator is quite straightforward with the only potential pitfall being the soldering of the IC sockets to the printed-circuit board. Since between-the-lead copper traces (see Fig. 2) were used on the board, extreme care must be taken when soldering to avoid solder bridges between traces. Refer to Fig. 3 to determine parts

USE STRANDED WIRE to hookup the circuit points on the printed-circuit board to the switch and jacks mounted on the front panel.

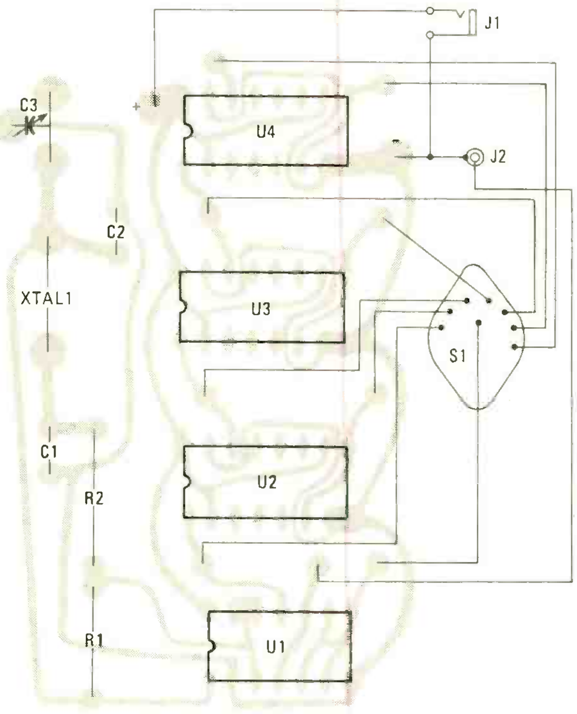


FIG. 3—PARTS ON-BOARD LOCATION and off-board hookup connections are shown in this easy-to-follow diagram.

locations and note that all components are installed from the non-foil side of the board.

Before installing any components, rub the copper side of the printed-circuit board with fine steel wool until the copper traces shine brightly.

Install the IC sockets in their correct positions, taking care to align the notched ends of the sockets with the end of the IC hole group having a nearby dot on the foil side of the board. Do that, and possible disoriented installation of integrated-circuit chips

Solder the IC sockets to the printed-circuit board (see Fig. 3). The soldering iron you use should be a fine-tipped pencil-type iron rated at about 30 watts. Be sure to use small diameter rosin-cored solder. Apply the iron nearly perpendicular to the board, behind the socket pins protruding through the board. Be sure to contact both the IC pin and copper trace. Allow the joint to heat up for a few seconds and then touch the solder to the junction between the iron and the socket pin. That method reduces the time necessary to heat each joint.

Solder should flow down the socket pin and blend into the copper pad on the board. If the solder does not flow down smoothly, allow the joint to heat up more before applying the solder.

If, after the smoke clears, you discover that you managed to bridge a few IC pins together, use "solder-wick" or a "solder-sucker" to remove the excess solder.

Insert all the remaining circuit parts in their correct locations (Fig. 3) and solder them to the board. Cut excess lead lengths with diagonal cutting pliers. Be sure that XTAL1 and trimmer capacitor C3 are flush with the board.

Drill the holes in the cover of the plastic case as detailed in Fig. 4. Install switch S1 and jacks J1 and J2.

Cut twelve wires three-inches long and strip 1/8-inch of insulation from each end. Locate the wires from the printed-circuit board to the mounted circuit parts on the cover illustrated in Fig. 3. The generator is now completely wired and ready for test.

Checkout and Useage

Insert the 5-VDC wall-plug power supply into J1 and plug the power supply into a wall outlet. Using a VOM, check each IC socket against the schematic diagram (Fig. 1) for correct +5V and ground return. If the measured voltages aren't correct, first check the wiring to J1 and then look for solder bridges on the printed-circuit board. After the voltages check out correctly, remove power to the board and insert the IC's into their sockets. To avoid damaging the IC's, it is important that the power to the board is off and that the IC's are installed such that the notch (or dot) on the top of the IC is at the same end as the foil dot on the other side of the PC board. As the IC devices are of a CMOS variety, precautions should be taken to avoid any accidental discharge of static electricity.

Connect an oscilloscope or frequency counter to J2, and reconnect the power to the board. Select all of the frequencies with switch S1. If any of the frequencies seem out of sequence, recheck the wiring to S1.

Check the 1 MHz output with a frequency counter and adjust C3 until exactly 1 MHz is generated. The accuracy should be respectable even without adjustment.

Push the finished board into the enclosure and screw on the cover. The flex of the interconnecting wires should provide enough tension to keep the board from rattling around. Before the project can be used, obviously some kind of test probe must be made up. I suggest that alligator clips be used on the end of a coaxial cable with corresponding BNC connector to allow for maximum utility and mobility. As for all those other pulse generators you have stashed away under the workbench or in the basement—junk 'em. The Crystal-Controlled Pulse Generator may be the only unit you'll ever use again. **SP**

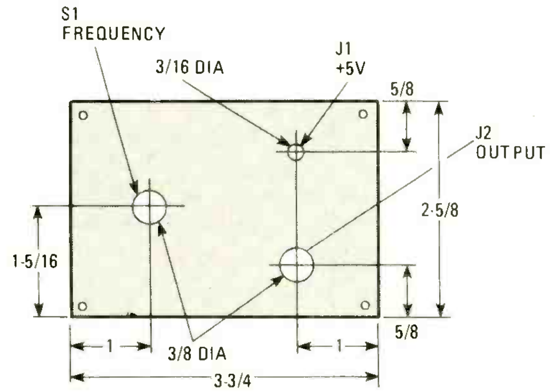
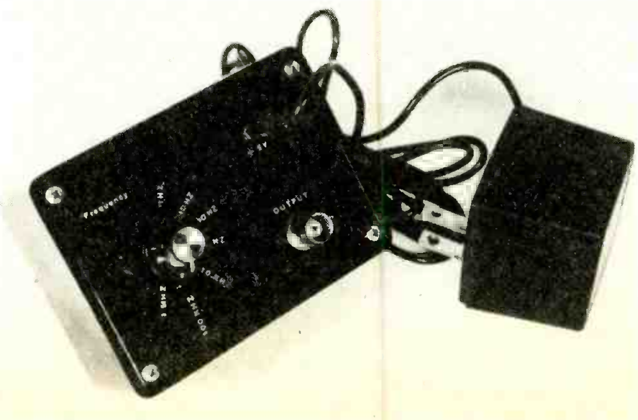


FIG. 4—THE FRONT PANEL hole location is provided here for those who want to make an exact copy of the author's unit.



HERE'S THE FINISHED UNIT all set to go! A standard 5-volt plug-pack power supply eliminates the need for batteries.

GOLF CART ODOMETER

**How long was that drive?
Is this hole really 325 yards, or is it longer?
How far do I chip with my eight iron?
Does the cart's battery need charging?
The answers to these questions can be had if you install this project on a golf cart!**

ELERY C. SMITH, JR.

□FOR THOSE OF YOU WHO PLAY GOLF, HERE IS AN NIFTY project that is sure to lower your handicap. This Golf Cart Odometer is triggered by a rear wheel of your golf cart, and the Odometer readouts in yards traveled. With a map of your golf course showing the trees, bunkers, and traps, you can very accurately record the distances while you ride along. You can also measure the distance of your drives, fairway shots, and chips. This Odometer may be used on comercial electric carts which then can alert the driver that much of the battery reserve has been used up.

How It Works

The forward movement of the golf cart for one revolution of the drive wheel can easily be measured. That measurement is used to set up a ratio of distance traveled in yards per revolution of the wheel. That number can then provide the number of yards traveled in one revolution. For example, if the forward distance is 53 inches-per-revolution, then:

$$53 \div 36 = 1.47 \text{ yards per revolution.}$$

A small magnet is attached to one rear wheel and a magnetic reed switch, S1, mounted so that for each revolution of the wheel, the switch provides a high signal to the counter, U1-U2 (see Fig. 1).

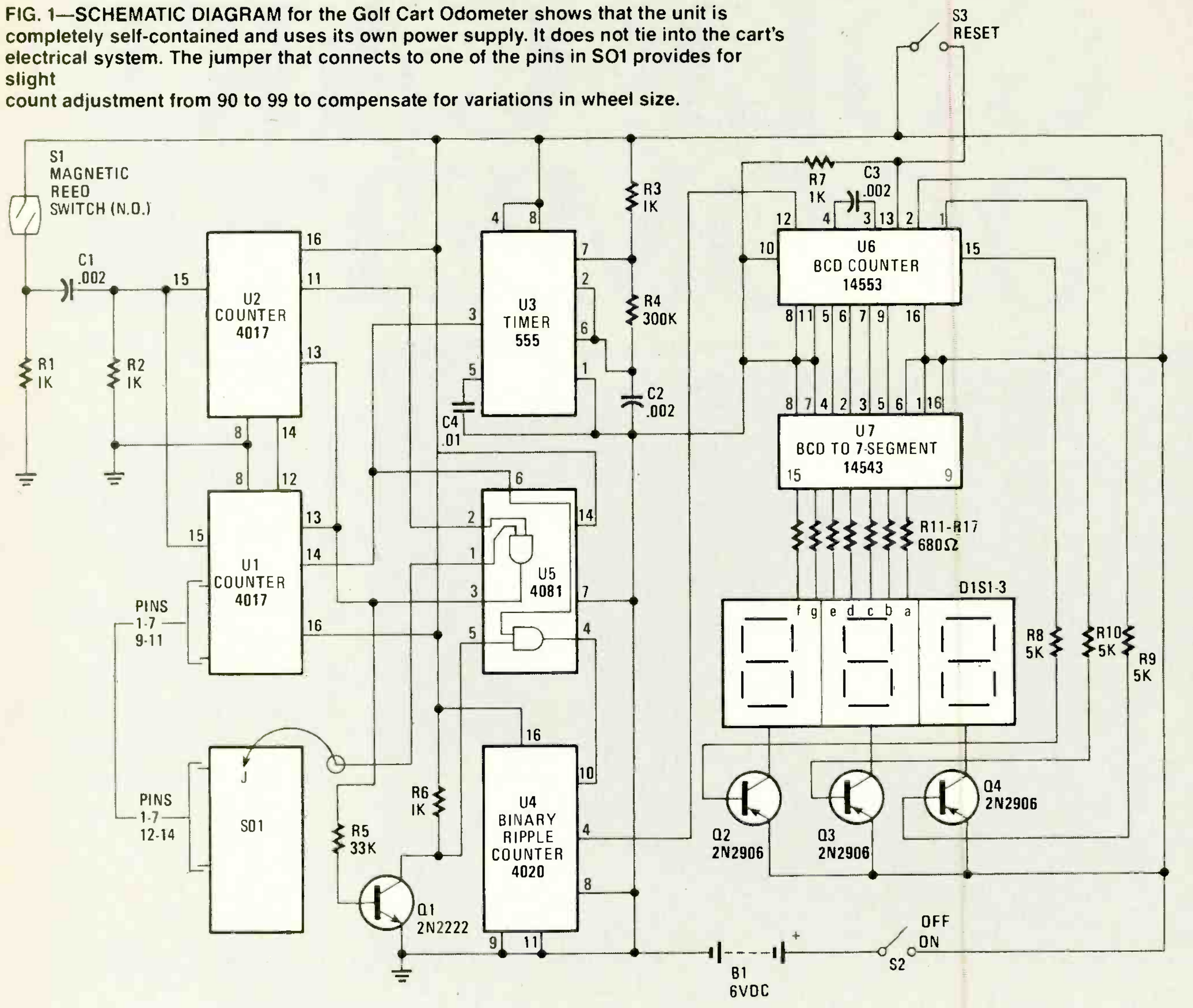
Since the objective is to get one count per revolution and then add them all together and obtain the number of whole yards, I'll step you through the schematic diagram (Fig. 1).

Begin with U3 which is a free-running, squarewave oscillator operating at about 12 kHz. That frequency is not critical so long as it is high enough to provide a little over a hundred counts to U1 per revolution of a wheel. The output of U3 goes to the counter, U1-U2, which is connected to count up to a specified value each time it is reset. As the wheel turns, the small magnet on the wheel (shown under the tape in the photo), closes the normally-open switch, S1 (shown mounted on the spring in the the photo).

The closing of switch S1 by the magnet resets counter U1-U2. The outputs of U1 and U2 are connected to the inputs of an AND circuit in U5. When U1-U2 reach the desired count (assume 95) then the output of the AND circuit in U5 goes high on pin 3 and that positive signal is applied to pins 13 on U1 and U2 which stops the count. That signal also goes to Q1 which inverts it and applies it to pin 5, another AND circuit in U5. During the time when U1-U2 was counting, the output of the oscillator, U3, was also applied to pin 7 of U5, the other side of the AND circuit that had the inverted output from U1-U2. (See Fig. 1)

As long as the output of the AND circuit connected to U1-U2 is negative, and the output of Q1 is high, then the output of the AND circuit on pin 4 goes high for every pulse from the oscillator which feeds a pulse to U4 (see Fig). 1. That allows

FIG. 1—SCHEMATIC DIAGRAM for the Golf Cart Odometer shows that the unit is completely self-contained and uses its own power supply. It does not tie into the cart's electrical system. The jumper that connects to one of the pins in SO1 provides for slight count adjustment from 90 to 99 to compensate for variations in wheel size.



U4 to count the pulses counted by U1-U2 in a cumulative fashion. U1-U2 counts to 95 and starts over each time it is reset by closing the reed switch, but U4 starts counting from where it left off. Pin 4 of U4 produces a pulse for every 64 pulses input. The outputs of U1 are connected to an empty 14-pin socket so a jumper can vary the U1-U2 count from 90 to 99 to compensate for minor variations that may occur in wheel diameters. That will be explained in detail in the calibration procedure.

The output of U4 is connected to a straightforward, 3-digit counter for display up to 999 yards. The RESET switch, S3, resets the display counter to zero.

Construction

The best construction technique is to use a printed-circuit board to hold the component parts in place. The printed-circuit board for the project may be made as one board and then cut apart (See Fig. 2).

The drawing for the printed-circuit board of the display does not show holes for pins 3, 4, 5, 6, 9 and 12 for the display diodes. Those pins are not used, and by clipping these pins off of the integrated-circuit sockets, it leaves more room for the circuitry.

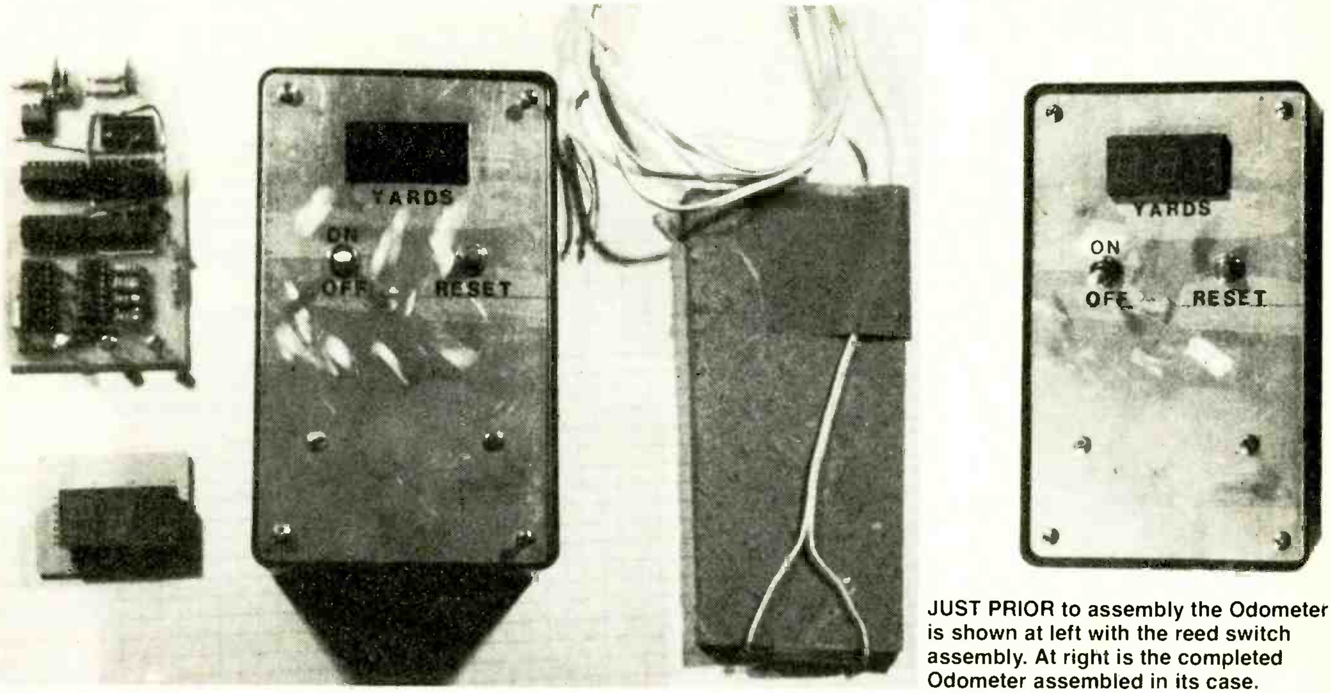
None of the parts values shown in the schematic diagram (Fig. 1) and the Parts List are critical. Most values were chosen because that was what I had in my junkbox. I recommend that the leads to the reed switch be sufficiently long so the readout box can be place anywhere in the golf cart. The battery holder is mounted on the back of the box's cover.

I tried several schemes to use the golf cart battery supply, but I was not able to eliminate transients—so occasional false readings would result. A separate power supply is the most stable design feature. The leads from the main printed-circuit board to the display printed-circuit board should be flexible and long enough to permit removal of the cover from the box.

Socket SO1 is used as the output of U1 so that you can vary the count slightly for accuracy. Make that jumper from solid wire that fits snugly into the socket hole. The wire should be about the size of an integrated-circuit pin. No. 22 AWG solid copper wire will work fine. Table 1 details the pin number in SO1 for specific counts.

On the component layout drawing (Fig. 3) note that pins 12, 13, and 14 of SO1 do not show a jumper attached to them. Those tie points should be jumpered to pins 9, 10 and 11 respectively of U1. Those jumpers are not shown because they would reduce the drawing's clarity.

I recommend that you connect the display board, RESET switch S3, and a 6-volt power source for a checkout before



JUST PRIOR to assembly the Odometer is shown at left with the reed switch assembly. At right is the completed Odometer assembled in its case.

installing the separate components in the box. Be sure the jumper in SO1 is in pin 7 for checkout procedure below.

Checkout and Troubleshooting

Once you have checked over your construction and are satisfied that the wiring has been done correctly, and all of the integrated-circuits chips are oriented correctly, then apply the 6-volt power. The display should light up, and RESET switch S3 should produce zeros. If that is the case, then move the magnet past the magnetic reed switch, S1, so as to actuate the reed switch 10 times. That should produce a readout of 15. You should get 1½ yards per closing of the reed switch. Reset the display and actuate the reed switch 20 times. That should produce 30 on the display.

If those things happen, you are ready to continue assembly and go through the calibration procedure. If those things did not happen, here is what you do. First, if you don't have a display, then check the voltages and interconnecting leads. If these are okay, check the transistors and integrated circuits for correct orientation. The multiplexer counter and associate circuit is straight forward; and if the circuit is wired correctly, the components are good, and voltages are correct, the Golf Cart Odometer will work.

Once you get a display that will zero, then jumper about 2μF across C2 to slow the oscillator down, then remove U4. Refer to Fig. 1. Check the output of U3 at pin 3 with a voltmeter. You should be getting about 1 second pulses that are going from zero to about 5 volts. When you get the oscillator to function, then connect a jumper from pin 3 of U3 to pin 12 of U6. Push RESET switch S3 and the display should

PARTS LIST FOR GOLF CART ODOMETER

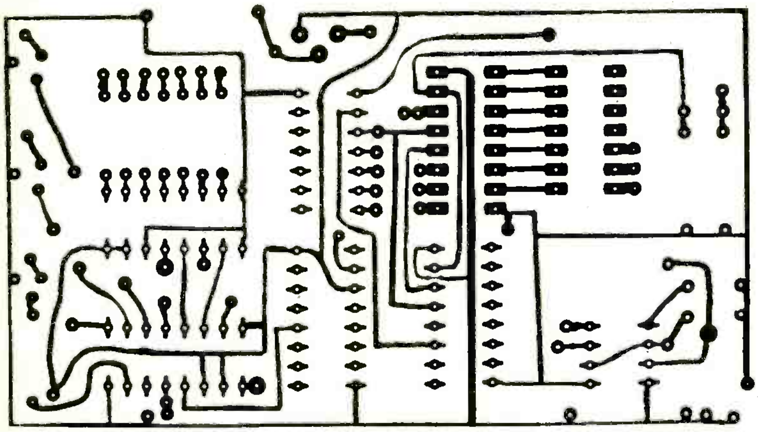
SEMICONDUCTORS
DIS1-DIS3—HP5082-7650 7-segment light-emiting diode display
Q1—2N2222 NPN transistor
Q2-Q4—2N2906 PNP transistor
U1, U2—4017 CMOS decade counter/divider integrated circuit
U3—555 timer integrated circuit
U4—4020 CMOS binary ripple counter integrated circuit
U5—4081 CMOS quad 2-input AND gate integrated circuit
U6—14553 CMOS 3-digit BCD counter integrated circuit
U7—14543 CMOS BCD-to-7-segment latch/decoder/driver integrated circuit

RESISTORS
(All resistors are ½-watt, 10%)
R1-R3, R6, R7—1000-ohm
R4—300,000-ohm
R5—33,000-ohm
R8-R10—5000-ohm
R11-R17—680-ohm

CAPACITORS
(All capacitors are 16-WVDC or better, ceramic-disc type)
C1-C3—.002-μF
C4—.01-μF

SWITCHES
S1—Glass magnetic reed switch, normly open
S2—SPST toggle
S3—SPST, normally-open, pushbutton

ADDITIONAL PARTS AND MATERIALS
Magnet, 6¼ × 3½ × 2-in. plastic box with aluminum cover, 5 16-pin IC sockets, 5 14-pin IC sockets, 1 8-pin IC socket, 4 AA dry cells, battery holder, printed-circuit board material, hardboard, screws, solder, wire, etc.



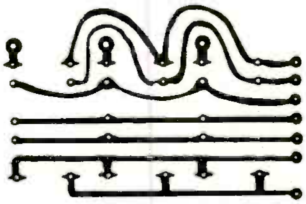


FIG. 2—FOIL-SIDE pattern for printed circuit board is shown here without interconnection between the two section. Etch the board as one unit, then cut apart. Leave room at edges of each board section for mounting holes as required.

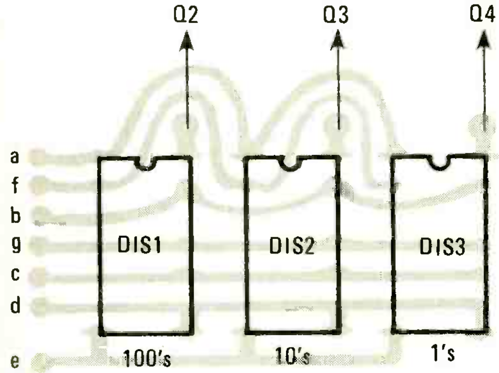
begin at zero and count pulses. If other than a sequential count occurs, then check the leads going to the display board from the output of the transistors. When you get the display counter to count properly, place a jumper from pin 10 to 4 at U4 socket (U4 still removed). Press the RESET switch to zero the display, then actuate the reed switch with the magnet. The display should count to 95 and stop. If it does, that indicates that U1-U2 and ¼ of U5 is functioning correctly.

The display counter can be used to monitor the outputs of U1 and U2 independently by connecting a jumper from pin 4 of U4 socket to pins 12 or 11 of U1 or U2 respectively. When you get that portion to function properly, replace U4 and remove the 2μF capacitor from C2. Of course, there may be troubles you can get into that I have not covered, but with a little imagination you are in good shape and a couple of holes up on your competition. Mine worked perfectly the first time.

Installation and Calibration

The installation is shown on a Club Car golf cart simply because that is the type I have. I have had it on the E-Z-GO type and it functions equally as well.

The magnet can be attached to the wheel in a permanent manner or taped so it can be easily removed. The only requirement is that it pass close enough to actuate the reed switch once per revolution. The same mounting applies to the reed switch, either permanent or temporary. The installation I will describe is temporary, because I like to move it from cart to cart. The best adhesive tape I found for holding the magnet to the tire is put out by U-Haul. They use it to seal boxes, and



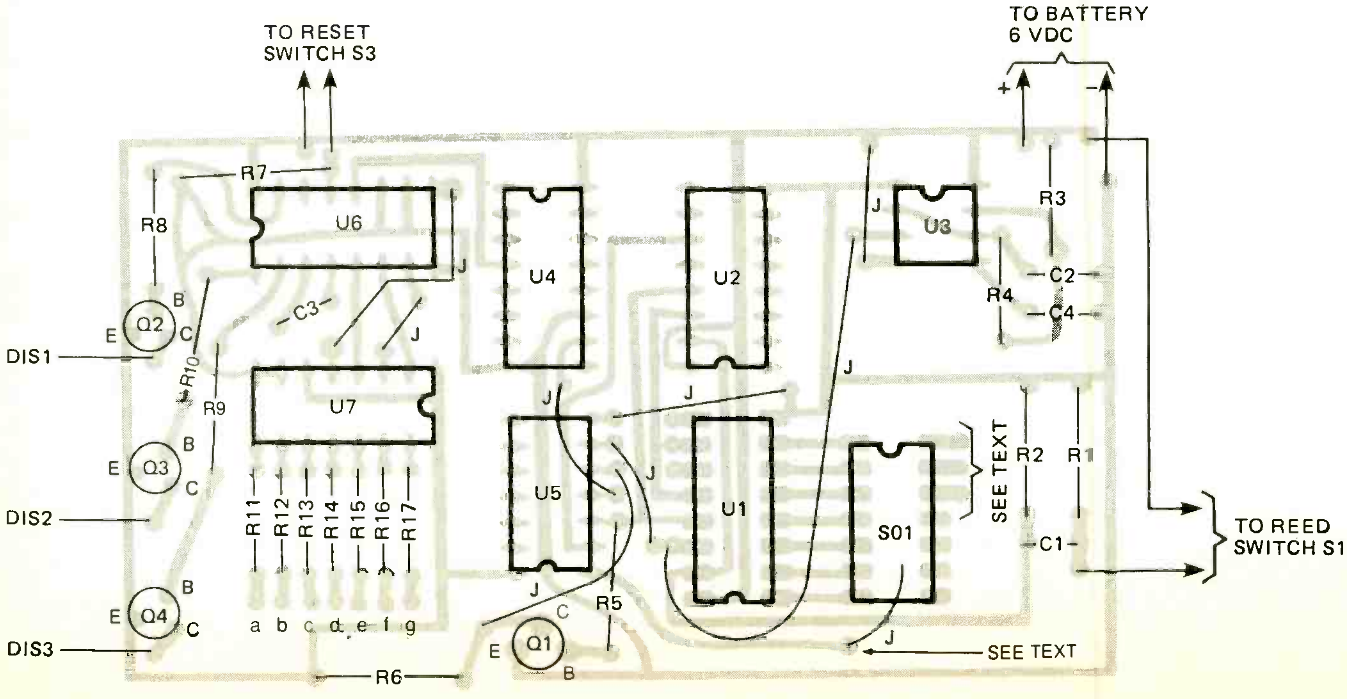
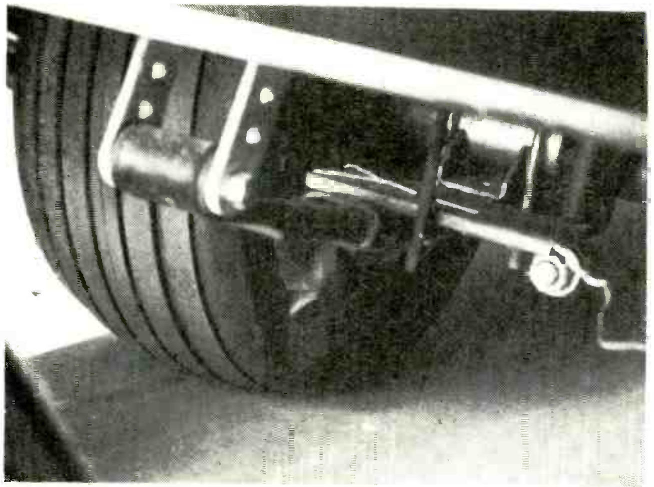
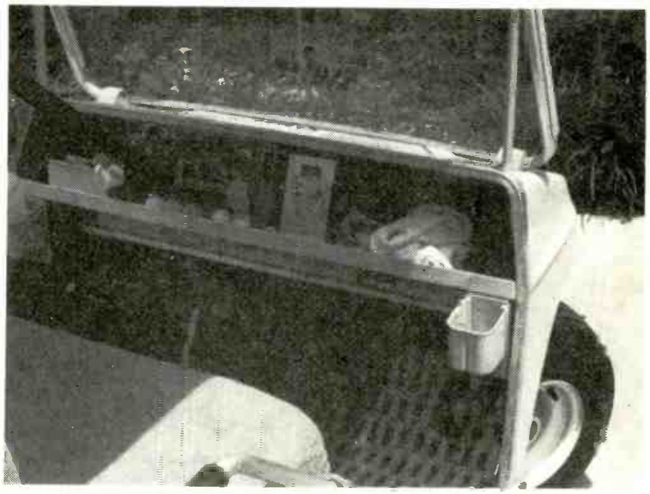


FIG. 3—PARTS LOCATION INFORMATION for each section of the printed-circuit board is given here with interconnection information. Connections *a* through *g* on the display section are made from resistors R11 through R17 on the larger section—refer to Fig. 1.



THE REED SWITCH is mounted on wood and secured to the spring suspension of the golf cart. Taped to the wheel is a magnet that passes near the reed switch each rotation.



TUCKED AWAY in the storage shelf in the dashboard area is the Golf Cart Odometer for both players to see. Snake wire cable under cart's carpet to the reed switch assembly.

I found it to hold the magnet to the tire better than any other. You can buy enough to last a lifetime (almost) for about a buck and a half.

Reed switch S1 is mounted on a piece of hardboard or other insulating type material so that it may be attached near the wheel. If S1 is attached to a piece of hardboard, and the hardboard can be held to the rear spring with a C clamp. That technique makes it easy to remove the S1 when when it is not needed. Each cart presents its own mounting problem

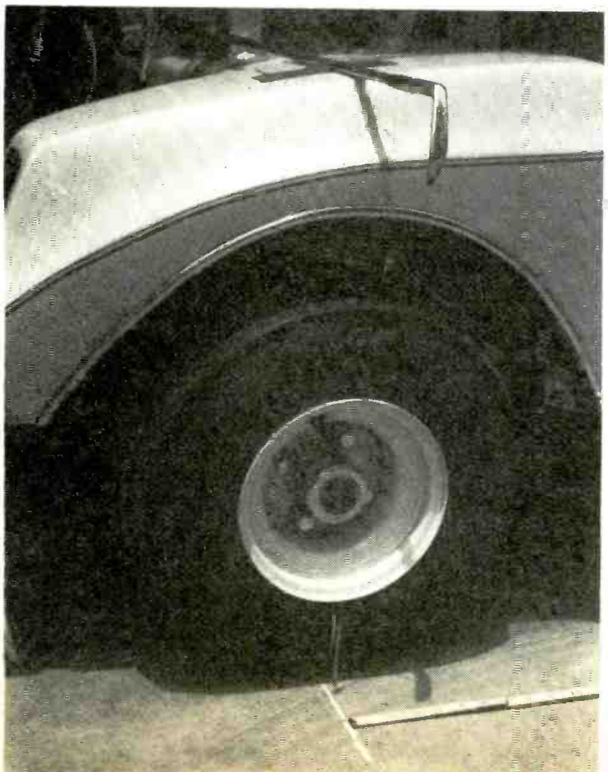
For the initial calibration, suspend a thread with a weight attached so that it bisects the wheel. A photo shows a thread attached to my 5-iron, and the thread has a nail on the end of it pointing to the chalk mark on the pavement. I cut the head off the nail and drilled a small hole in it for the thread. After you get the thread with the weight bisecting the wheel and hanging down near the pavement, make a chalk mark at the bottom of the tire and on the pavement where the weight points. Roll the cart forward exactly one revolution of the wheel and make another chalk mark on the pavement where the weight points. Now, the distance between the chalk marks is the number of inches your cart travels per revolution. Use the ratio mentioned earlier to set the counter U1-U2 and you are ready for a test run. Here is an example. Suppose you measured 55 inches for your distance, then:

$$55 \times 1.78 = 98$$

So, the jumper in SO1 would go at pin 2. Remember the count on the U1-U2 starts at zero, so back down one count to 97 to start your test runs on a measured

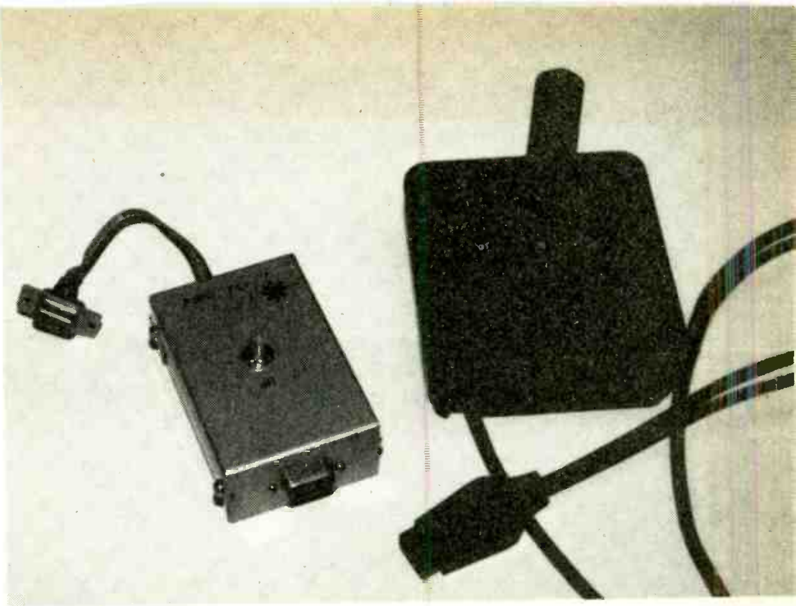
(Continued on page 96)

THE TEXT gives detailed information on how to calibrate the Golf Cart Odometer. The photo at left shows a plumb line dropped through the centerline of the rear wheel to find the mark on the wheel and starting point. After one rotation, with the mark and plumb line aligned, you'll know exactly how many inches the cart travelled. The photo on the right shows this clearly. The author used a 5 iron, you can use any stick you care to use!



Build FIRE-FLI

JIM STEPHENS



—an automatic firing circuit for your Atari VCS that'll keep your stingers and rays zapping aliens and dragons faster than you can blink!

NOT ALL VIDEO GAMES ARE CREATED EQUAL. THAT IS especially true of some of the games written for the *Atari 2600*. Did you ever notice that some games have features that others don't? Why do some of the more intricate games leave out things like automatic restart, or automatic fire while holding down the fire button? The reason is simple: They ran out of space in the VCS memory. But all is not lost; we can still have some of those important functions. All we need to do is to add a few electronic circuits to take up where the game maker's software quits.

Some games for the Atari *do* have automatic firing. That function is found in *Demon Attack* and *Space Invaders*, for example. Firing operates automatically when the fire button is held down. Not only does that function save wear and tear on the joystick, but also wear and tear on the fingers, and thus, permits longer playing periods without fatigue. The first week that my two boys had their Atari, I thought I would certainly die of thumb cramp from squeezing the fire button.

My favorite game, *Defender*, does not have auto-fire. The circuit described in Fig. 1 adds that important feature and makes that game a thrill to play. The two IC's in the heart of Fire-Fli turn *Defender* into a wild frenzy of zap or be zapped.

Circuit description

The Atari joystick has a total of six connections. One of those, marked F in Fig. 1, is the ground for the power supply. By shorting various combinations of the remaining five connections to F, all the different functions of the control stick (joystick) are obtained.

The *fire* button operates by shorting connection F and E. Therefore, to get the joystick to fire repeatedly, a circuit must be devised that will short those two lines at a fast rate and not interfere with other functions of the control stick. That can be handled using two inexpensive and readily available integrated-circuit chips, the 4066 bilateral switch and the 555 timer chip. Though several other components and miscellaneous parts are needed, the basic parts are few and the basic electronic circuit is quite simple and easy to construct.

The 4066 chip contains four independent switches that have a very high resistance when their control pins are held at ground. By connecting one side of a switch to the F connection and the other side to the E connection, we have the means to short those two lines together by just varying the voltage on the control pin from positive to negative. The voltage switching can easily be done with the 555.

Fig. 1 illustrates the components and connections that are necessary in order to make the 555 timer, U1, oscillate at a rate determined by the value of R2. A value of 20,000 ohms was chosen for R2 because that value gives a fire rate of about five cycles per second. Another value may be substituted here for different rates or that could be a variable resistor in the 25,000-ohm range.

PARTS LIST FOR FIRE-FLI

SEMICONDUCTORS

U1—4066 CMOS quad bilateral switch integrated circuit
U2—555 CMOS timer integrated circuit

RESISTORS

(All resistors are ¼-watt, 10% fixed units)
R1—100,000-ohm
R2—20,000-ohm

ADDITIONAL PARTS AND MATERIALS

C1—1-µF 16-WVDC, electrolytic capacitor
S1—DPDT slide switch (See text)
1—Female RS232 9-pin type D subminiature plug (RADIO-SHACK 276-1538)
1—Male RS232 9-pin type D subminiature plug (RADIO SHACK 276-1537)
Small utility box or plastic case, board (1 × 2-inch) made from perfboard, 2—pin soldertail, IC sockets (Radio Shack 276-1999), 6-strand ribbon cable or flexible hook-up wire, battery—4.5V Duracell alkaline #PX21 (see text), ⅛-inch miniature phone plugs (optional power connection, see text)

NOTE: A complete set of components less case, battery and phone jacks is available from SYNTRONICS, 2324 Dennywood Drive, Nashville, TN 37214. $15.50

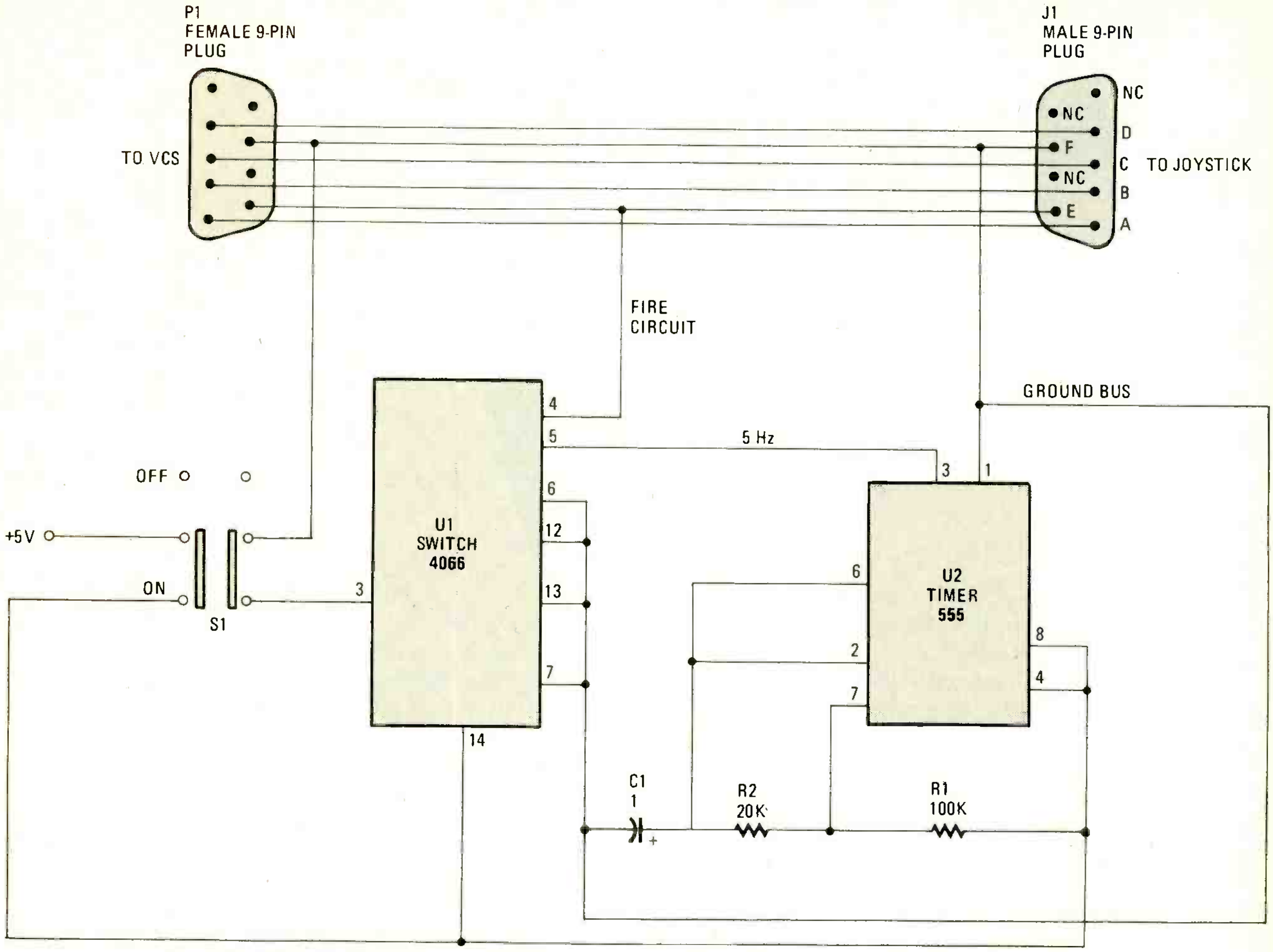


FIG. 1—SETTING S1 to the ON position powers the add-on circuits. Resistor R2 sets the timer rate at about 5 shots per second. One of the quad switches in U1 grounds bus E to actuate a missile firing.

As U1 oscillates, a positive-going pulse is output at pin 3. That pin is connected to the 4066, U2, control pin to turn its internal switch on and off. The other control pins of the 4066 (6, 12, and 13) are grounded to keep the output of the other switches off, and thus not affect the one which we are using.

Some means of powering the two chips must be provided. I chose to use a 4.5-volt "C" cell because I was trying to fit the circuit into a very small case (an idea I discarded). A 9-volt transistor battery could be used but might make it necessary to change the value of R2 for the correct frequency.

Another (less expensive) method would be to borrow the power from the VCS. That could be done by placing a matching power jack into the Fire-Fli's case and extending a power lead through the case to the VCS which would be terminated by a matching power plug.

The Fire-Fli circuit pulls only 2.5 mA, so the battery should last a fairly long time depending on the amount of use.

Circuit Wiring Method

Since there are so few connections and components, this would be an excellent time to etch a small printed-circuit board. I chose to use a perforated board with .100 spaced holes and to wire point to point. I used two 14-pin soldertail sockets for the integrated-circuit chips. Figure 2 shows the layout of the five components whose placement on the board is not critical.

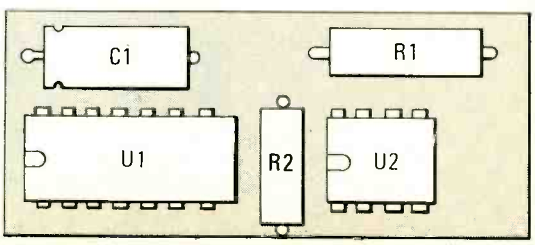
The two matching RS232 plugs that connect the joystick and the VCS are directly wired using an eight-inch length of 6-lead ribbon cable, or using regular hook-up wire.

The switch should be a double-pole, double-throw since it is actually doing two jobs: It disconnects the power supply and disconnects the F lead from the 4066 chip, U2 and controls power. If the power jack was installed, some expense could be saved on the switch since it would only have to be a single-pole, single-throw to disconnect the F lead.

The case, or chassis box, can be most any that you might have available and could easily be just a small plastic parts box. I used an aluminum utility box.

Operation and Checkout

Once the circuit is wired, check the wiring closely—an error in wiring the power could throw direct power into the VCS, and could harm the VCS system. Be very careful when



THE CIRCUIT FOR FIRE-FLI is so simple, no printed-circuit board was designed. The author used a piece of scrap perfboard and came up with the parts layout shown.

FIRE-FLI fits neatly into a small aluminum chassis box and has only one operating control—the power switch, S1. In those games where excessive firing scores against the player, or causes a penalty delay should the shot miss the target, set the switch at OFF, and the joystick returns to normal operation.

connecting the power leads. Double check to make sure that the correct pins on the chips have the right voltage because they can be ruined if wired incorrectly.

The joystick should be connected to the male RS232 plug, P1, and switch S1 should be set to OFF. Plug the female RS232 jack, J1, into the VCS and verify that the game is working normally—that is, the game joystick controls and fire button provide normal game situations. If not, the circuit has a problem and the wiring should be checked again before the Fire-Fli is energized.

If the fire button and the other functions operate correctly, the switch is set to ON and automatic firing should start immediately. If not, turn the Fire-Fli off, open the chassis box, and recheck the unit's wiring.

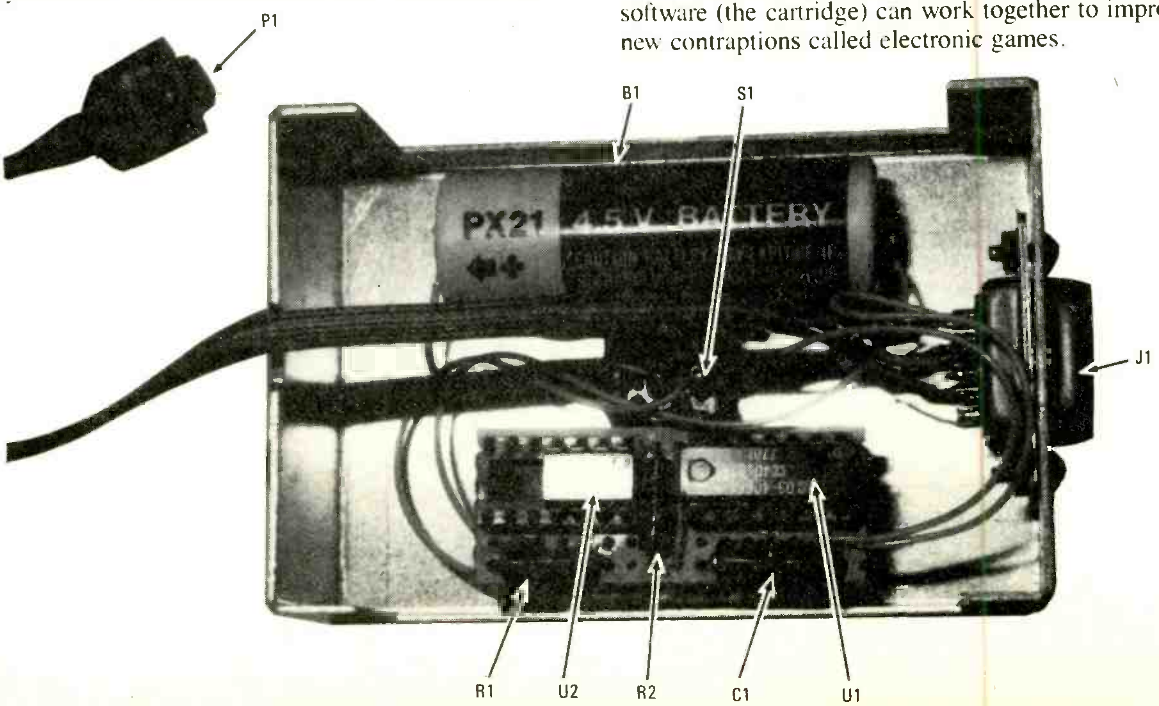
It might be that the 555 oscillator, U1, is failing to start. If all the wiring appears to be correct, it might be that you might have to try different values for the other two components to get the oscillator to start consistently. Try varying the value of resistor R2. I've not had a problem there, however.

Automatic fire can create various problems with some games. With *Defender,* for example, if the defender ship is moved below the horizon, all your smart bombs will be used in less than two seconds. That can be avoided, however, by holding down the fire button. That stops automatic fire and can be a very handy feature at some points in game play.

Your Game Improves

Of course, proper use of the joystick with the Fire-Fli will demonstrate that you are an *electronics genius*, and will make your game scores quite higher than others. But, more important, it will add new spice to games that have become boring and have not been taken out of the game-cartridge storage case for some time.

The construction will also demonstrate that hardware and software (the cartridge) can work together to improve those new contraptions called electronic games. **SP**



A PEEK INSIDE the Fire-Fli reveals that the battery takes up more space than the circuitry. One source of possible wiring error would be the interconnection of matching terminals on J1 and P1. Check the wiring carefully against the schematic diagram in Fig. 1. Variations of the layout should produce no problems.

Variable Pulse Generator

A basic circuit that'll provide the timing pulses for many future projects—By Warren Baker

THE BEGINNING ELECTRONICS EXPERIMENTER USUALLY needs some sort of a pulse generator as part of a project or special gadget. To an equal degree, even the experienced builder will require such a device quite often. Although the Variable Pulse Generator circuit described is not the ultimate one may desire, it may just be simple enough to do the job in most cases, and it is the beginning circuit for many other pulse and timer circuits.

The circuit of the Variable Pulse Generator shown here in Fig. 1, in fact, is a textbook circuit, and no claim is being made for originality. It is easy to duplicate on a solderless breadboard, vector board, or even by point-to-point methods if one should desire.

The physical layout shown has been drawn by making use of Global Specialties Corp. experimenter board layout paper. See Fig. 2. By following the connections as shown it is simple to reconstruct the circuit on your own solderless breadboard system. In the event you want to use the circuit either as is, or after your own modifications, it is an easy matter to quickly transfer the circuit—piece by piece—directly to Global's EXP-300-PC pre-etched and drilled Circuit-board with no changes. Soldering the leads on the back side of the board will complete the construction and leave you with a working model of the circuit.

As a rule it will not be practical to mount the two potentiometers (R1 and R2) on the printed board. Therefore, they are shown as a sub-assembly with but three wires to be connected to the main board. These variable controls may be mounted on a panel, the front of any enclosure you may use, or elsewhere. Both R1 and R2 will interact when adjusted. It would be best to connect a scope to the output (pin 3) and observe the changes caused by each adjustment.

In addition, if you connect the output to an audio amplifier, more amplification will be gained. As the unit now stands, it will tune over a range of approximately from 5 Hz to about 5 kHz. A different frequency range can be selected by merely changing the value of the timing capacitor, C1. In addition, by placing another pair of potentiometers in series with each of the others, increased frequency range and better adjustment will result. Make these new controls about 50,000-ohms or 100,000-ohms. They will be handy when using resistance values in the lower ranges. Set the 1-Megohm units to minimum and make adjustments with the 50,000-ohm units.

The circuit parts-value parameters of the Variable Pulse Generator are not critical and most parts values can be juggled or substituted to fit the stock already in your junk-box. Since the timing is proportional to the product of the resistors and timing capacitor *(Continued on page 99)*

PARTS LIST FOR VARIABLE PULSE GENERATOR

C1—.1-µF, 15-WVDC Mylar capacitor
C2—.01-µF, 15-WVDC ceramic capacitor
C3—20-µF, 15-WVDC electrolytic capacitor (see text for details)
R1, R2—1-Megohm, ¼-watt potentiometer
U1—555 timer integrated-circuit chip
1—Global Specialties breadboard system EXP-300-PC circuit board (or any substitute product, or perfboard)
Plus—enclosure, wire, batteries, knobs, solder, hardware, etc.

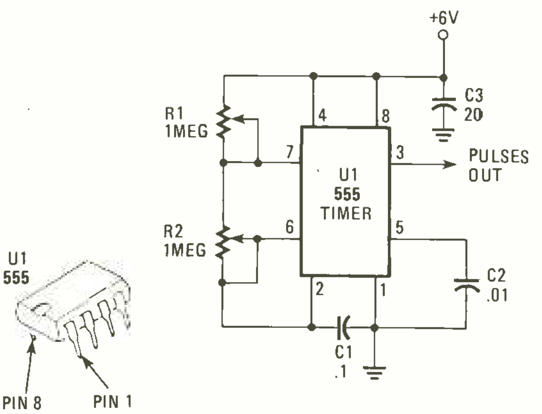


FIG. 1—LOOKS SIMPLE, it is simple! This basic Variable Pulse Generator circuit will be used again and again in your future projects. Get to know it, and use it, now!

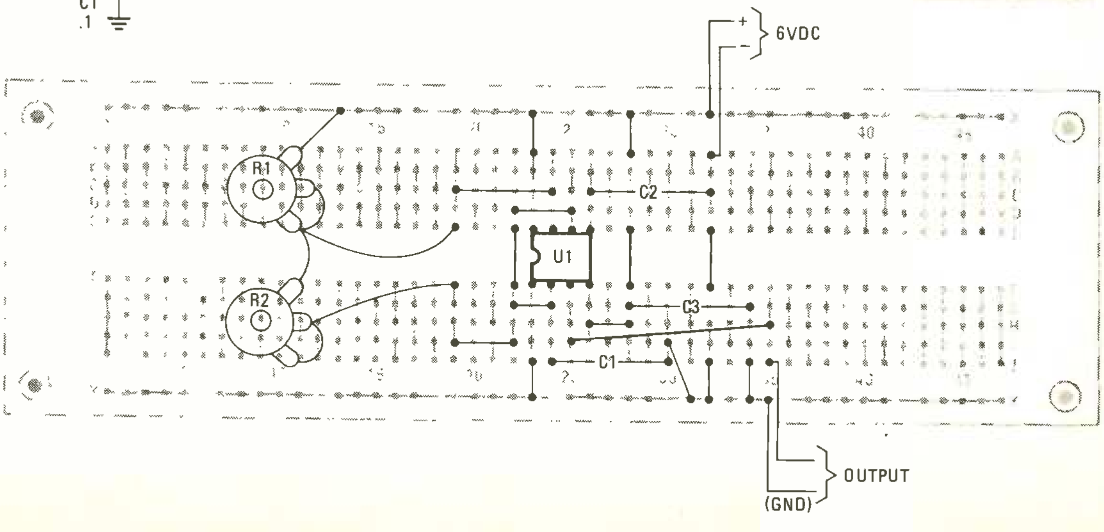


FIG. 2—PARTS layout is shown here for a Global Specialties solderless breadboard. Unmarked line are electrical jumpers.

NEW THIS ISSUE

Calling All Hams

6, 10, AND 15 METERS ARE THREE EXCITING ham bands. Activities are many; variety abounds. There are clubs, networks, contests, and repeaters. One can ragchew, experiment or perform a service. Local and DX QSO's are possible.

All of the above can be accomplished at QRP and lower power levels, and with minimal QRM. Antennas are small and manageable. In terms of results, equipment costs can be better matched to money available. Tri-band 6-, 10- and 15-meter equipment and antennas are becoming available. Some include WARC 12-meter capability, too. Perhaps 12 meters will be activated in a year or so. For the present, join the three-band fun.

Six meters is excellent for local ragchewing (AM or SSB) with low power, simple units and simple aerials. It is also an active FM-repeater band, especially for mobile and portable operations. There are numerous VHF contests that involve 6 meters, including the new, popular grid activities. Various propagation anomalies occur on 6 meters at various times, kicking off periods of DX excitement.

Ten meters, as propagation conditions change daily, seasonally, and with sunspot cycles, provides local, medium-distance and long-distance contacts at low-power levels. Such is possible without the overwhelming QRM problems found on lower frequency bands. On 10 meters tehre is a growing long-distance FM-repeater excitement. Also you can give a listen to signals coming back from the ham satellites. There are numerous local and single-band DX contests that occur on 10 meters.

Of the three bands, 15 meters provides the most reliable DXing. WAC and DXCC awards are possible at QRP level on sideband, and on CW at QRPP level. It is an exciting band for DX contests. Reliable long-distance schedules can be kept on 15 meters if you make reasonable seasonable adjustments and don't expect too much during summer months and low-count years of the sunspot cycle. Nevertheless it is a fun-DX band.

Antenna Mount for 6-10-15

Antennas for 6-10-15 can be simple, cheap, space-saving, easy-to-build, and effective. That is still another reason for having your ham fun on those high-frequency bands. Begin with a CB steel whip (Radio Shack 21-903), a luggage-rack mounting bracket (Radio Shack 21-937), some hook-up wire, and a couple PVC piping sections. For 10-meter resonance cut five inches off the top of the whip; you can use a metal saw, bolt cutter, or fencing-wire cutter. The rack mount is bolted to one end of a 10-foot section of 1½-inch diameter PVC piping. The other end of that section telescopes two foot into a 10-foot section of 2-inch diameter PVC piping to serve as a mast. Entire assembly is lifted over a 5-foot metal fence post (Sears). Refer to Fig. 1.

Four radial wires, each 3 inches longer than the vertical are made from vinyl-covered #16 hookup wire. Assembly details are shown in the photographs. Note that the bracket is held to the piping by two long bolts that pass through the PVC piping (Fig. 2). The backup plate of the bracket is not used.

The radials are connected to the bracket; use solder rings held tight by two shorter bolts that pass through the remaining two holes of the bracket (Fig. 3). The other end of each radial ties to one end of an insulator. Similar size hookup wire connects to opposite side of insulator, stretching out to a ground stake. The four

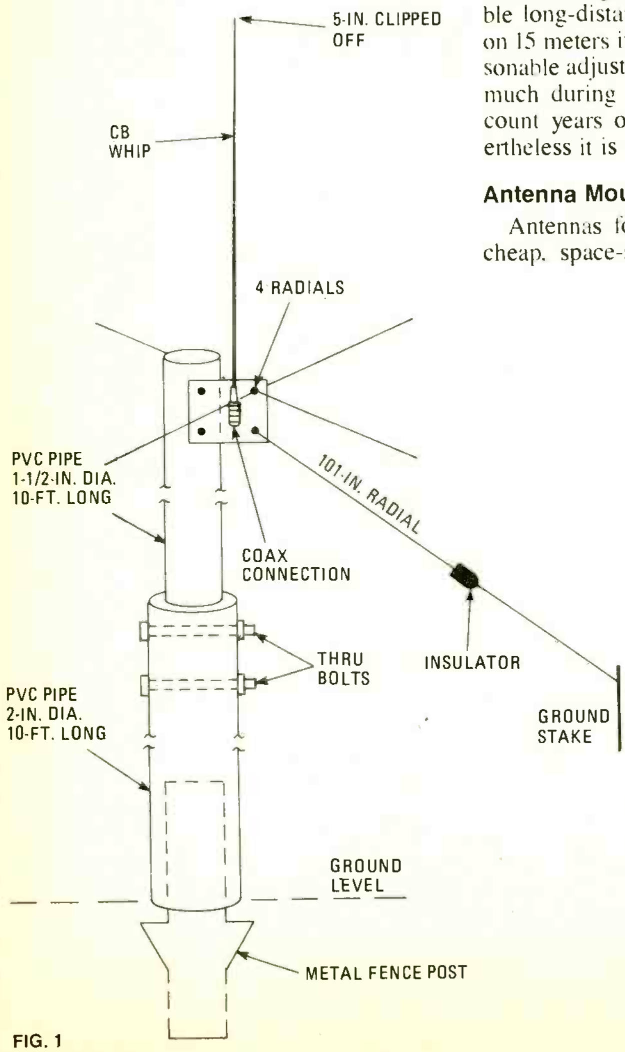


FIG. 1

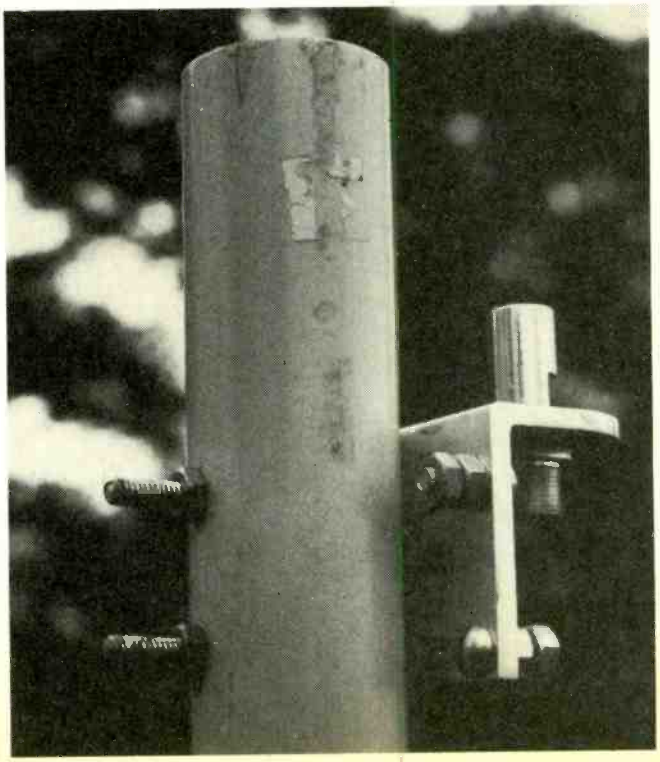


FIG. 2

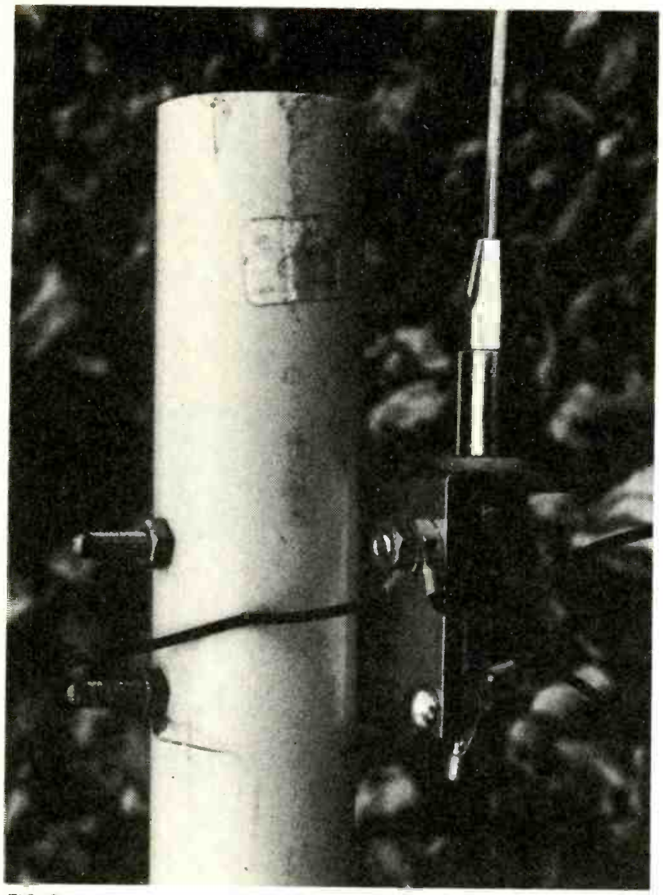


FIG. 3

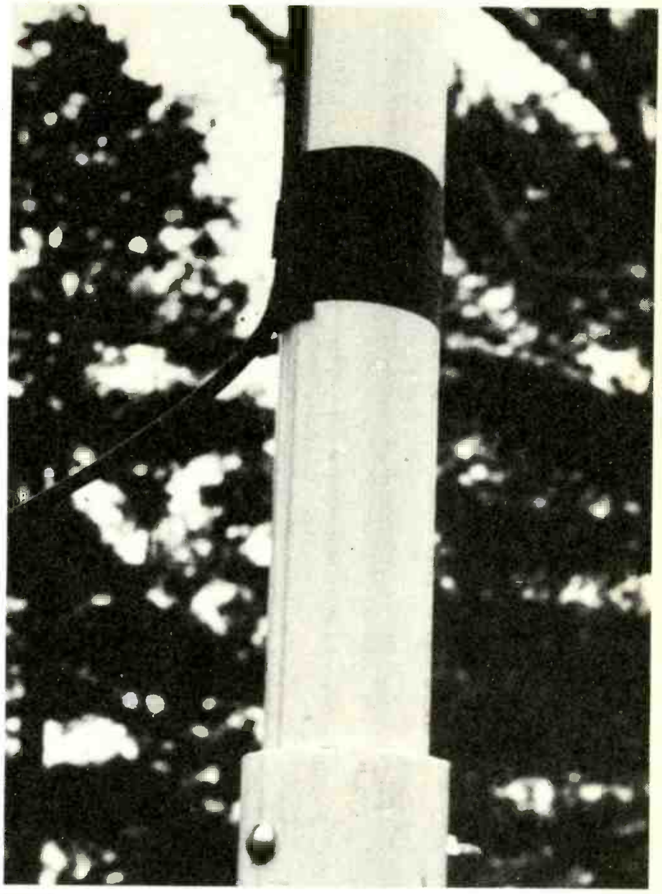


FIG. 4

radials also act as a complete guying system for the very light mast.

In the construction process the top section of PVC piping is slipped two feet into the bottom section and is held in position by two through bolts separated 1½ feet. Refer to Fig. 4. The coaxial line is taped to the mast above this jointure and continues into the radio shack (your station location, not the store).

The entire aerial/mast assembly is light, and can be lifted up and down easily. It can be moved about, because all that needs to be done is to remove or drive another fence-post into the ground at some other location. Versatility can be helpful in construction of two or more phased verticals, with the added advantage that they can be moved about freely to change the pattern orientation. The experimental advantages of that type of construction are obvious.

If you are interestted in three-band operation, construct three individual verticals in the same manner. Run different lines to a 3-position coaxial switch mounted near your operating position. If further economy is in order, cut three individual steel-whip verticals. When changing bands, you can let down the mast and substitute the individual whip. You need only purchase a single luggage-rack mounting bracket.

Helpful dimensions are given in the table. Those include quarter-wave vertical dimensions for various segments of the three bands as well as lengths that must be added to or subtracted from the length of the CB whip. It should be noted that for 15-meter operation the vertical should be about 28 inches longer than the CB whip. That added section can be obtained from the cut-off part of a vertical you prepare for 6-meter operation. It can be cut properly and tightly wire-wrapped to the top of the full-length CB whip to obtain the desired overall length. Wrap very tightly and tape. In our experiments, we fashioned a top hat from a 58-inch length of #16 solid hookup wire (vinyl covered), removed several inches of insulation from each end, and tightly wrapped it around top of the mast below the tip, taped tightly. Then a circle was shaped and its center taped at bottom as shown in Fig. 5. Just tape; do not remove insulation at this point. Enjoy 3-band operation, picking the options of operating mode and activities they provide.

ANTENNA DIMENSION CHART

MHz	Mode	Ft.	In.	CB Diff.* (In.)	Radial Length (In.)
15 METERS					
21.1	CW	11.1	133.1	+29.9	136.5
21.3	SB	11.0	132.0	+28.8	135.2
10 METERS					
28.6	SB	8.2	98.2	−5	100.7
29.55	FM	7.92	95.0	−8.2	96.2
6 METERS					
50.5	—	—	55.6	−47.6	57.0
52.0	—	—	54.0	−49.2	55.5
53.5	—	—	52.5	−50.6	54.0

*Length to be added or removed from standard 103.2-inch CB whip antenna.

Wrap-up

It will be my pleasure to visit with you in each issue. Emphasis will be on items that will help you learn and participate in ham-radio activities at reasonable cost. A wide variety of topics are to be covered. Antennas will be a mainstay because of the overwhelming interest in the topic. If you like, send us a note about some of the general-interest subjects that will keep you reading this column. —*Ed Noll*

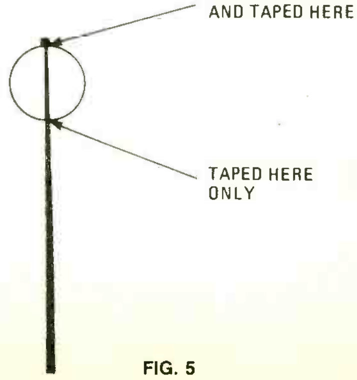


FIG. 5

POCKET PULSE GENERATOR

Trigger frequency from .1 Hz to 10 MHz, and pulse output from 40 nanoseconds to 10 seconds

D.E. PATRICK

☐ARE YOU IN THE MARKET FOR A GOOD POCKET PULSE generator? If so, before you buy one check out our project's specifications. You may end up building the Pocket Pulse Generator.

Our home-brew generator (see Fig. 1) has maximum trigger frequency range around 10 MHz down to 0.1 Hz or less in four continuously variable ranges, with a separate pulse width output from 40 nanoseconds (ns) up to 10 seconds (s), or more, in four continuously-variable ranges. The Pocket Pulse Generator specifications are: standard TTL or optional 50-ohm output impedance, jitter under 0.01%, rise and fall times around 8 ns, battery operated, slips in your shirt pocket, and uses only one integrated circuit. Further, the two ½-74LS123 one-shot chips may also be operated cross-coupled as shown in Fig. 2, or 74LS221's may be used in pin compatible, albeit functionally different circuits, as in Figs. 3 and 4. More on those later.

The 74LS123 Version

In Figs. 1 and 2 chip U1-a triggers itself. That is, the $\overline{Q}$ signal out of U1-a, ½-74LS123, is coupled back to the B input. Thus, $\overline{Q}$ going high triggers U1-a with around a 50 ns to 30 ns fall through. Repetition rate of the trigger pulse to U1-b (pin 10) is determined by the setting of R1, R2, capacitors C1 thru C4 and C6. U1-a's $\overline{Q}$ output tied to its B input provides an extremely short duration retrigger pulse.

In fact, if C9 is deleted, the time between output pulses will be dependent on the delay around U1-a, which can empirically be in the 30 ns range. A 500- to 250-pF capacitor for C9 will slow things down so you can at least see it on a scope. Therefore, U1-a's $\overline{Q}$ output makes an ideal test input to the Glitch Stretcher*. Where the value of C9 is small, an extremely short duration negative-going pulse is available at U1-a's $\overline{Q}$ output, with R1, R2 and C1 thru C4 then setting the time interval between pulses.

U1-b is configured as a monostable multivibrator triggered by U1-a's $\overline{Q}$ output. Its output pulse width is determined by R3, R4, and capacitors C5 thru C8.

Optional emitter followers Q1, Q2 and Q3 (see Fig. 1.) provide a low-impedance output. Thus, build-out resistors R8, R9, and R10 determine the output impedance. 50-ohm outputs are standard for lab stuff, while 75-ohm outputs are standard for video and service-grade stuff. You could use standard 51-ohm resistors, or 50-ohm resistors can be selected from 47- or 49-ohm junkbox units, if desired, and 75-ohm resistors can be selected in the same way

In the 74LS123, the output pulse width (t_w) is a function of the external components R1, R2, and selected capacitors C1 thru C4 for U1-a and R3, R4, and selected capacitors C5 thru C8 for U1-b. For values of C_x (capacitors C1 through C4 and C5 through C8) equal to or greater than 1000 pF, the output pulse t_w = KRC, where K is nominally 0.45 for Vcc = Vrc + 5, and C is in pF with R in kilo-ohms giving t_w in nanoseconds. (See Table 1 if you don't want to do the math.)

Now, when C_x is greater than 1000 pF, and R_x (R1 plus R2) is greater than 5000-ohms and less than 260,000-ohms for a 74L123 (R_x is greater than 5000 ohms or less than 160,000 ohms for a 74123 chip), the change in the constant K with respect to R_x is insignificant. However, when C_x is less than 1000 pF, K will change when Vcc and Vrc are connected to

*Glitch Stretcher, p. 90, Special Projects No. 5, Winter 1983 edition. A few copies are still available at $4.00 plus $1.00 for postage and handling.

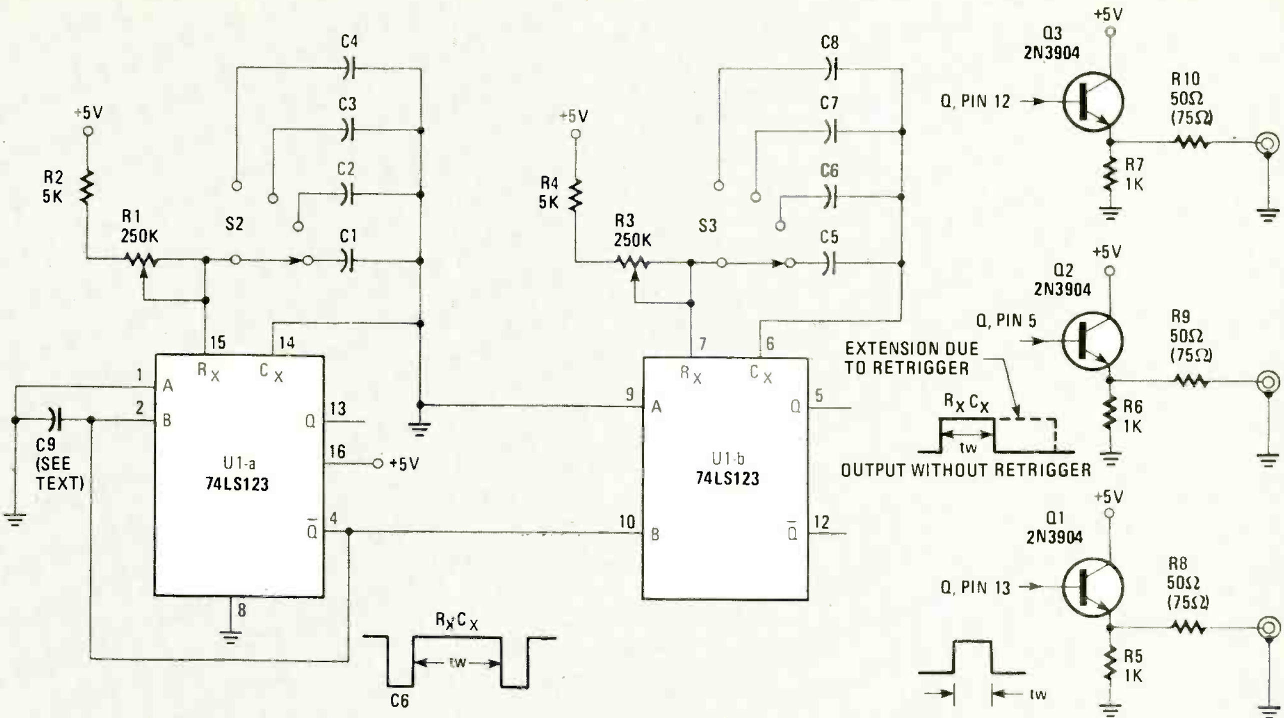


FIG. 1—BASIC CIRCUIT for the Pocket Pulse Stretcher showing optional low-impedance emitter followers.

TABLE 1—74LS123 SAMPLE VALUES

t_w for $R_{minimum}$ 5000-ohms (Seconds)	t_w for $R_{maximum}$ 260,000-ohms (Seconds)	C_X
2.94×10^{-7}	1.47×10^{-5}	100-pF
2.25×10^{-5}	1.17×10^{-3}	.01-μF
2.25×10^{-3}	1.17×10^{-1}	1-μF
2.25×10^{-1}	1.17×10	100-μF

Expected t_w's for the 74LS123, where the C_X is equal to or less than 1000 pF, then $t_w = 6 + 0.05C_X + 0.45R_XC_X + 11.6R_X$, and for C_X equal to 1000 pF or greater, $T_w = 0.45R_XC_X$.

TABLE 2—74LS221 SAMPLE VALUES

t_w for $R_{minimum}$ 1400-ohms Seconds)	t_w for $R_{maximum}$ 100,000-ohms (Seconds)	C_X
9.8×10^{-8}	7.0×10^{-6}	100-pF
9.8×10^{-6}	7.0×10^{-4}	.01-μF
9.8×10^{-4}	7.0×10^{-2}	1-μF
9.8×10^{-2}	7.0	100-μF

Expected t_w's for 74LS221, where t_w is approximately $0.7C_XR_X$

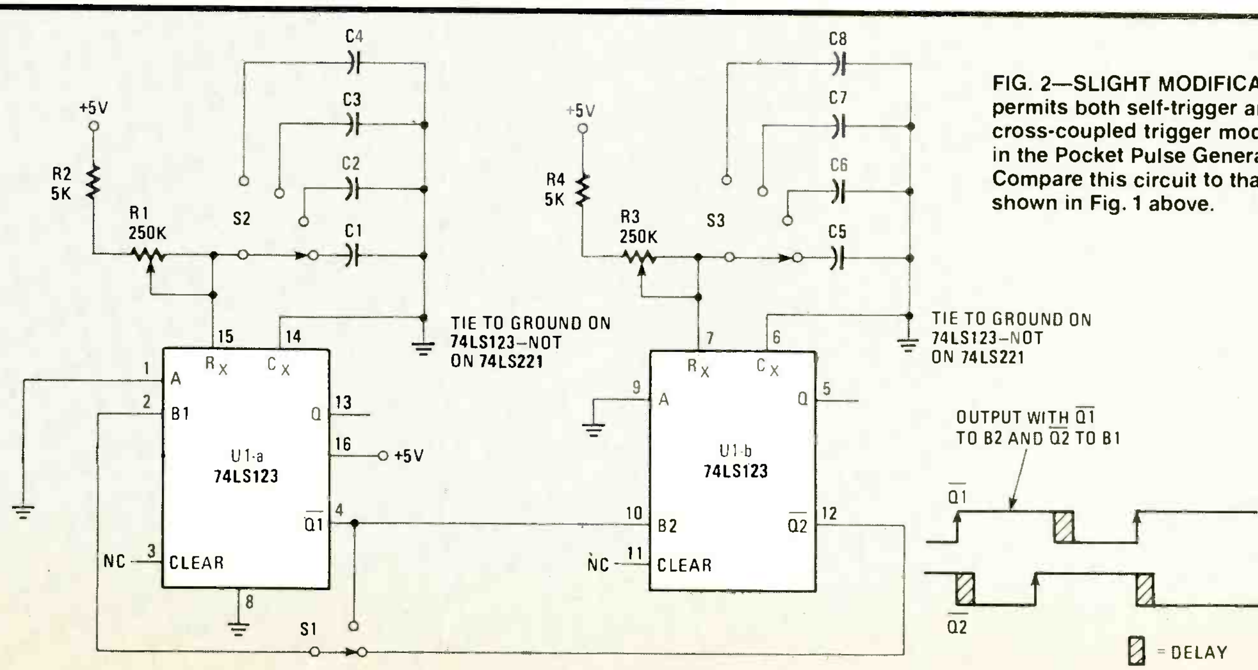


FIG. 2—SLIGHT MODIFICATION permits both self-trigger and cross-coupled trigger modes in the Pocket Pulse Generator. Compare this circuit to that shown in Fig. 1 above.

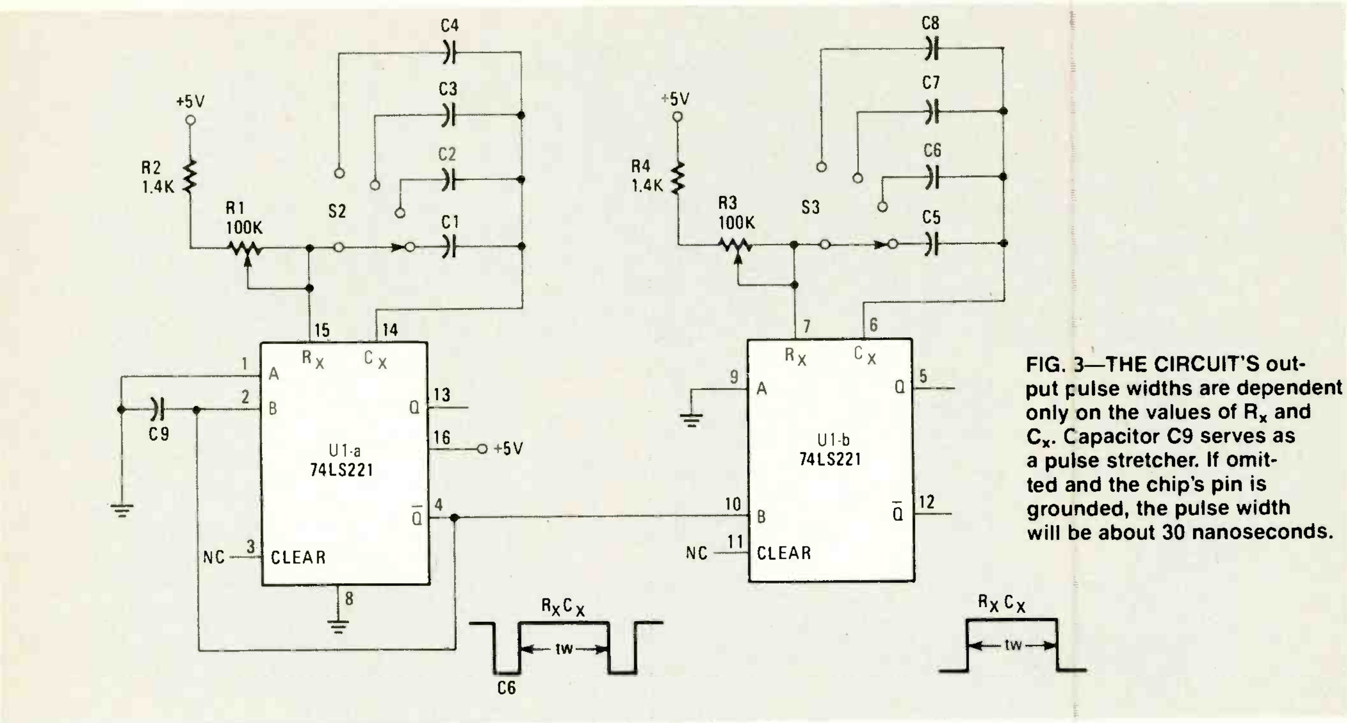


FIG. 3—THE CIRCUIT'S output pulse widths are dependent only on the values of R_x and C_x. Capacitor C9 serves as a pulse stretcher. If omitted and the chip's pin is grounded, the pulse width will be about 30 nanoseconds.

the same supply. Then, t_w may be approximated by the following equation:

$$t_w = 6 + 0.05\ C_x + 0.45\ R_x C_x + 11.6\ R_x$$

where t_w is in nanoseconds, R_x is in kilo-ohms, and C_x is in pF. (See Table 1 to avoid the math.)

Cross Coupling

Now, U1-a and U1-b may also be operated cross-coupled, cut the trace from U1-a's $\overline{Q}$ output to its input and tie U1-b's $\overline{Q}$ output to U1-a's B input. Also, adding a SPDT switch, S1, as in Fig. 2 allows both self-trigger and cross-coupled trigger modes.

74LS122 Version

As with the 74LS123, when replaced by the 74LS122, the output pulse (t_w) is a function of the external components R1, R2, and selected capacitors C1 thru C4 for U1-a, and R3, R4 and selected capacitors C5 thru C8 for U1-b. However, t_w is calculated by a new formula:

$$t_w = C_x R_x(\ln 2) \approx 0.7 C_x R_x.$$

See Table 2 if you don't want to do the math.

Although the 74LS123 and 74LS221 circuits look to be pretty much functionally equivalent, they are not. The pulse width in the 74LS123 version in Fig. 1 can be programmed by

(Continued on page 96)

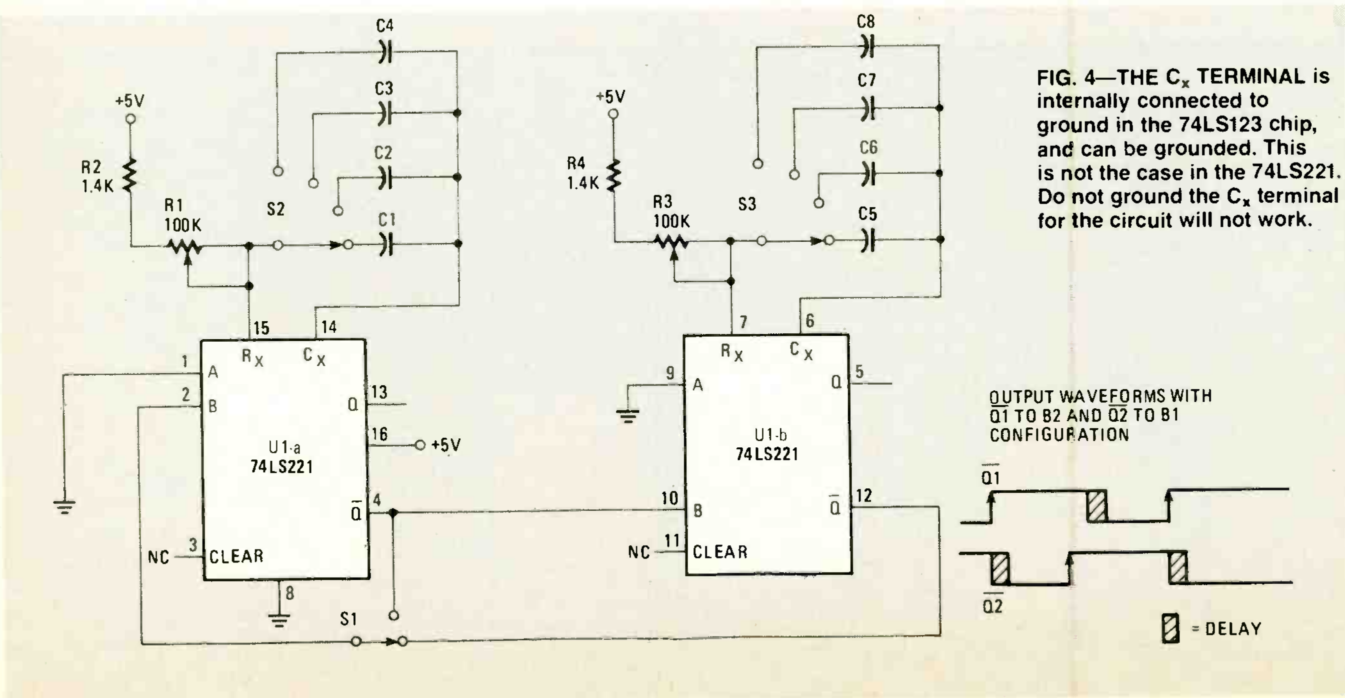
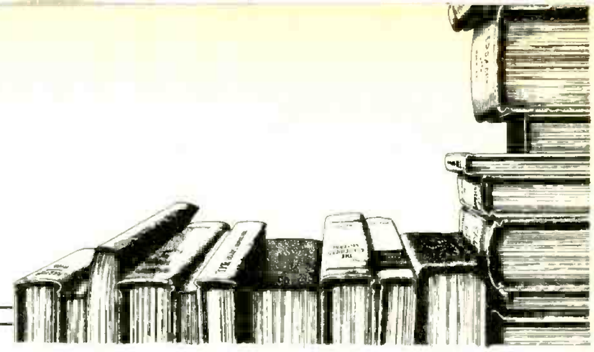


FIG. 4—THE C_x TERMINAL is internally connected to ground in the 74LS123 chip, and can be grounded. This is not the case in the 74LS221. Do not ground the C_x terminal for the circuit will not work.

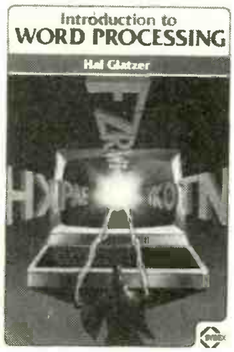
The Bookshelf



Introduction to Word Processing
by Hal Glatzer

Introduction to Word Processing makes learning about word processors interesting and enjoyable. This book tells you: What a word processor is, what it does, how to use one, and how to choose one.

You'll find out just how electronics has revolutionized the handling of words and information. If you are thinking about

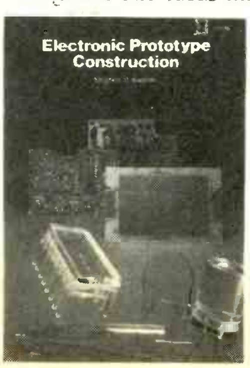


buying a word precessor, have just started using one, or want to get the most from the one, author Hal Glatzer's book is for you! Hal Glatzer is a journalist and television producer with a Master's degree in Communication. He describes himself as an "explainer," helping non-technical people to understand the information industries.

Published by SYBEX Inc. (USA), 2344 Sixth Street, Berkeley, California 94710. $8.95, paperback.

Electronic Prototype Construction
by Stephen D. Kasten

While many books are being written about the design of microcomputer and computer interfacing circuits, very little practical information is available about construction techniques for converting schematic diagrams and ideas into functional electronic prototype units. *Electronic Prototype Construction* was written to fill that gap. The text could be divided into four major features: Wire-wrapping, printed-circuit boards, graphic techniques, and hardware packaging

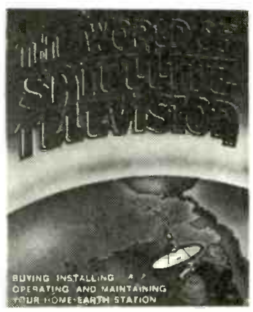


Author Stephen D. Kasten is a chemist with the Tennessee Eastman Company in Kingsport, TN. He has experience in the use of computers in laboratory automation. Steve's main computer interests center on the 6502 and LSI-11 computer systems and their interface circuits.

Howard W. Sams & Co., Inc., 4300 West 62nd Street, Indianapolis, IN 46268. $17.95, paperback.

The World of Satellite Television
by Mark Long and Jeffrey Keating

Now you can explore the exciting new horizons of satellite television from your home. As many as one hundred video channels of entertainment, news, sports, movies, and international television are all available at the flick of a switch. *The World of Satellite Television* provides everything you'll need to know: Selecting, installing, and troubleshooting a system; what's up there to see and how to find it; plus DBS, and other future innovations coming your way. The book's simple down-home approach, along with its



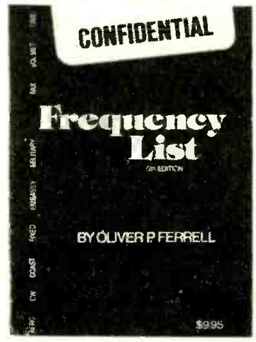
maps, charts, and satellite "footprints" make *The World of Satellite Television* a valuable reference guide for the accomplished video enthusiast as well as an easy introduction for the newcomer.

Mark Long and Jeffrey Keating are recognized authorities on international electronic communications. They are the authors of numerous magazine articles and publications, including a nationally distributed satellite TV column, and the million-selling *Big Dummy's Guide to CB Radio*.

The Book Publishing Company, Summertown, TN 38483. Paperback, 224 pages, $8.95.

Confidential Frequency List--
5th Edition
by Oliver P. Ferrell

The *5th Edition* of the *Confidential Frequency List* has been greatly expanded in terms of number of frequencies and stations, ancilliary remarks, and a wholly new section of the book devoted to a reverse listing by callsign, location, ser-



vice, mode and frequency(ies). The number of details entered in the *5th Edition* exceeds 100,000 items concerning 8500 frequencies and stations.

In the past 20 years, numerous changes have occurred in the use of the high frequency (HF) spectrum. Two-way HF communication has become more affordable, greatly expanding the "usage base." Stationary satellite relays have siphoned off a majority of the RTTY press broadcasters and many of the large radiotelephone links between continents. However, it has also become apparent that there is a vulnerability in satellite communications--especially for the military and ships at sea. Diminution of the number of HF circuits due to the switchover to satellites has not taken place--nor can it or will it take place. Shortwave--regardless of its modest shortcomings--is here to stay.

Oliver P. ("Perry") Ferrell has been monitoring the HF and VHF radio spectrum for over 48 years. Perry has been an author (400+ articles and editorials), editor (*Popular Electronics*, *Stereo Review* and *CQ*), researcher (USAF) and is now Chief Executive Officer of Gilfer Associates, Inc.

Gilfer Associates, Inc., P.O. Box 239, 52 Park Avenue, Park Ridge, NJ 07656. Paperback, 224 pages, $9.95.

Handbook of Practical Electronic Circuits
by John D. Lenk

If you are working with electronic cir-

(Continued on page 99)

GOLF CART ODOMETER

(Continued from page 85)

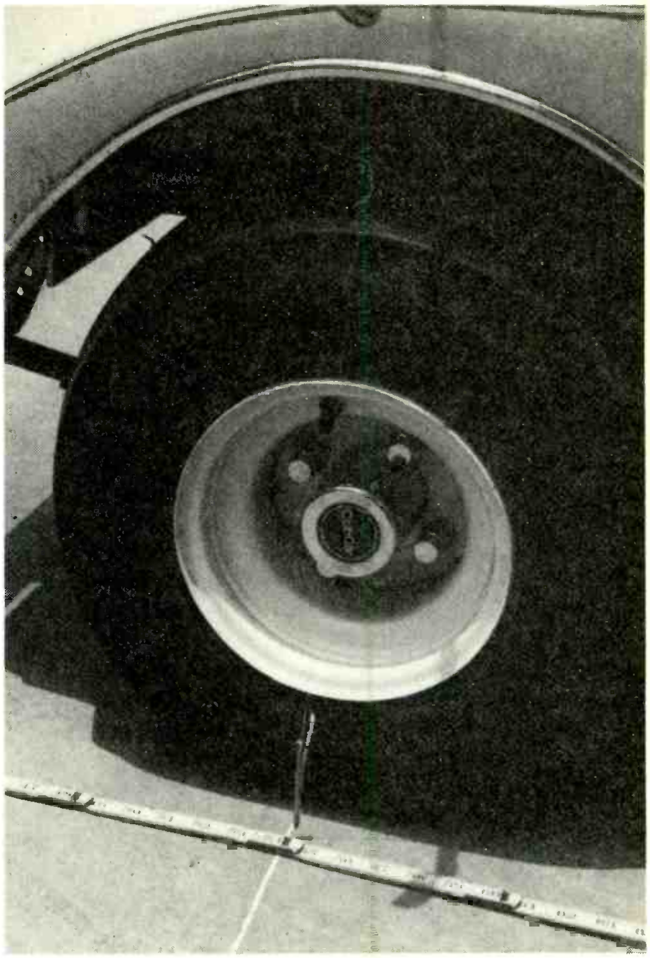
track. Substitute your measurement into the above formula where I have the 55.

A shortcut here is that you can put the jumper in SO1 where Table 1 shows 95, then go direct to your measured track and in about 3 or 4 runs on a measured track, you can tell where the jumper should go. You can tell whether you should increase it or decrease it.

A word of caution—measure off your own test track. I have found the measurements on the golf courses are sometimes off as much as 10%, which was one of the motivating factors behind the Golf Cart Odometer.

I recommend at least an one-hundred-yard test track for calibration, and you should make several runs. If you consistently read higher or lower than your measured distance, then change the counter U1-U2 jumper one count at a time until you are within about 1 percent.

Once you get it calibrated, keep your head down when you swing, practice your putting, and a lower score is truly in order provided you don't design and make an electronic stroke counter! *Good golfing!* **SP**



HERE IS A closer view of how the author measured the rotation of one revolution of the golf cart's rear wheel. Note that the plumb line that is used as a pointer to indicate the inches travelled also lines up with the center of the wheel and the chalk mark on the tire.

POCKET PULSE GENERATOR

(Continued from page 94)

selection of R_xC_x, *and once U1-b is triggered, the width may be extended by retriggering B2 high before it times out. Thus, the duty cycle could be extended to 100%. Alternately, the clear input could be used to shorten pulses. On the other hand, once the 74LS221 U1-b in Fig. 3 is triggered, its outputs are independent of further trigger transitions and are determined solely by* R_x *and* C_x, *albeit the clear input could be used as described above.*

Output pulse width using the 74LS221 can be varied from around 30 ns minimum, where $R_x = 2000$ *ohms and* $C_x = 0$ *to about 70 seconds, with a duty cycle less than 50%. Rise and fall times are independent of pulse width in both devices. However, the 74LS221 is typically the more stable of the two types with a pulse width less than 0.5% from device to device. In the 74LS221, the duty cycle is defined as* $100(t_w/T)$, *where T is the period of the input pulse. When input duty cycle varies between high and low values (not possible in these configurations), the output will vary in length or jitter. However, jitter is independent of* C_x *and for large values of* R_x *until duty cycle gets close to 90% in the 74LS221.*

The C_x *terminal in 74LS123 is internally connected to ground, but some manufacturers recommend* C_x *also be hardwired to ground. If this done, it should be noted that the 74LS221 will not work in the same circuit and will malfunction. See Figs. 3 and 4. No switching diode is required for 74LS123 and 74LS221 devices when large capacitances are used for* C_x. *However, the diode is required for 74123 devices. Also, if you use a junkbox 74123 in place of a 74LS123, keep in mind that because of a larger* R_x *in the latter case, it is possible to cover a wider range for* t_w *with a smaller number of capacitors, which is also true when comparing 74LS123 to 74LS221. This, coupled with the fact that mini-rotary switches were used, allows a pocket-sized package with a wider range than is possible with the 74LS221 version.*

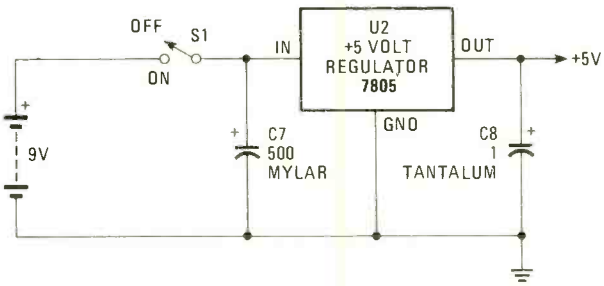
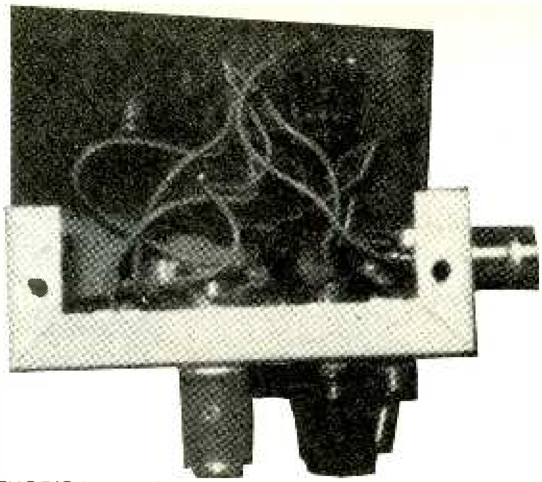


FIG. 5—HERE'S A UNIVERSAL power supply for TTL projects that require low-current drains. A 9-volt battery provides the omph and the regulator circuit makes it TTL compatible. That's all you need to power the Pocket Pulse Generator.

Construction Hints

It should be noted that when remoting R_x and C_x, they should be kept as close as possible to the chip's output terminals, keeping any inductance between the R_x/C_x junction and pinout to a minimum. There is no problem with this in the pocket-sized version, but if you opt for something bigger, it's worth remembering.

There is nothing critical about building the Pocket Pulse Generator--whatever version you may make. Keep the size small. Proper layout of the front panel is important. A positive 5-volt DC power supply (see Fig. 5) powered by a 9-volt transistor battery keeps that portion of the circuit miniscule so that the final unit will fit in a mini-chassis box. The one used by the author measured 3¼- × 2⅛- × 1⅛-inches. Be sure everything is going to fit before you start drilling holes. Since the reader will be selecting those portions of the Pocket Pulse Generator circuit he desires to assemble, a complete parts lists cannot be supplied. However, the schematic diagrams provide sufficient information so that a parts list can be prepared from the diagrams provided with the text. **SP**



AUTHOR'S Pocket Plus Generator is shown with the lid off and a home-brew, printed-circuit board lifted up. Other parts are crammed into the area behind the front panel.

100-MHZ SCOPE PROBE

(Continued from page 36)

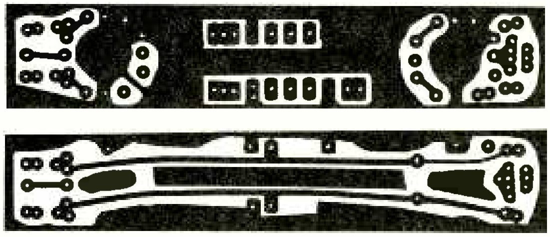


FIG. 6—THE FOIL PATTERN details closely approximate those required for your project. Should you copy it, be sure to align the holes for the top and bottom surfaces. Keep leads short if you design your own.

But the real beauty of the circuit lies in U2, an NE592 video amplifier, which is a pin-for-pin replacement for the NE733. The NE592 has an adjustable gain from less than 1 to over 100, and can have bandpass, lowpass, highpass, and other forms of filtering added, while the NE733's minimum gain is 10. In any case, rise time for the NE592 is generally in the 2-ns range with propagation delays in the 3-ns range, which can be improved by device selection. U2 feeds U3, another LH0033, which is an optional line driver.

Potentiometers R4 and R9, the offset adjusts for U1 and U3, are used to set the probe's output to 0 volt with 0 volt input at the probe's tip, and potentiometer R5 adjusts the gain of U2. Capacitors C1, C2, C3, C4, C5, C6, C7 and C8 are used as power supply RF by-pass capacitors. The probe runs on a dual ±5-to-6-volt power supply, because of the voltage supply requirements of U2.

Construction Tips

Layout of any high-frequency, high-gain probe is critical. The 100-MHz Scope Probe is no exception. For best results, use the double-sided printed-circuit board layout in Fig. 6 as a guide. Monolithic, low-inductance ceramic and/or tantalum capacitors are recommended along with 5%-tolerance, film resistors and miniature potentiometers which can be mounted as close as possible to appropriate IC pins.Components are mounted on both top and bottom sides of the small circuit board while IC's are mounted on the top. Parts location information is not given due to the several options available. However, signal tracing is simple, and you should have no problems.

The 10-MHz Scope Probe's outer case can be plastic, a cigar tube, etc., but an inner metal shield tube should also be employed. The inner shield should be a brass tube tied to ground and made to physically touch U1 and U3. That can be done safely with some desoldering braid secured to the brass tube and touching the IC's when the probe is assembled. **SP**

JENSEN ON DX'ING

(Continued from page 14)

abound in station identifications in many languages: *Aqui* (here is) in Spanish; *Huna* in Arabic; *Goverit* in Russian.

The word for *radio* remains, more or less, familiar sounding in a number languages, though the pronunciations do vary—phonetically—from *ray-dio* to *rah-dee-oh* to *rahd-yo*, and beyond!

Remember, too, that in foreign-language broadcasts, many other words will sound familiar to you regardless of the actual language. Often the names of prominent persons in the news—Reagan, Andropov, etc.—will be easily intelligible and will pop out at you like a light in a fog in the midst of an otherwise unintelligible news broadcast. The same is true of many place names. Such tipoffs can identify a news broadcast that you're hearing.

Political commentaries often are delivered with a tell-tale intensity of emotion, often with shouts and patriotic slogans. Dramas, with sound effects, bridge music between scenes, and the distinctive back-and-forth dialogue can be spotted in any language. Many Latin stations carry soap operas in Spanish for audiences every bit as devoted to them as we are to ours.

And musical programs, of course, use the international language that needs no explanation, much less translation.

If you actually want to learn a language for listening purposes, it's probably wise to concentrate on just one or two of the most-heard languages, such as Spanish, French, or Portuguese. It's also possible to learn a language by radio, with on-the-air lessons broadcast by some stations. Or you can rely on home-study books, records or tapes; high school, college, or night-school classes.

However you do it, by making an effort to learn a bit more about other languages, you will really expand your SWL'ing horizons.

English Programs

If you're not ready to chase after the non-English-speaking stations, here are a few targets for you with English programming:

Albania—*Radio Tirana* at 0000 hours GMT/UTC on 7,065 kHz.
Austria—*Austrian Radio*, Vienna, at 0330 on 9,770 kHz.

Bulgaria—*Radio Sofia* at 0000 on 11,720 kHz.

China—*Beijing Radio*, Beijing (Peking) at 1100 on 9,820 kHz.

Ecuador—HCJB, Quito at 0100 on 9,745 kHz.

Finland—*Radio Finland*, Helsinki, at 1500 on 15,400 kHz

Greece—*Voice of Greece*, Athens at 0130 GMT/UTC on 9,865 kHz.

Holland—*Radio Nederland* (actually relayed by a transmitter on the island of Bonaire in the Netherlands Antilles, off the northern coast of South America) at 0230 on 6,165 kHz.

Israel—*Kol Israel*, Jerusalem, at 2000 on 11,655 kHz.

Poland—*Radio Polonia*, Warsaw, at 0300 on 9,525 kHz.

Portugal—*Radio Portugal*, Lisbon, at 0300 on 6,060 kHz.

Romania—*Radio Bucharest* at 0400 on 9,510 kHz.

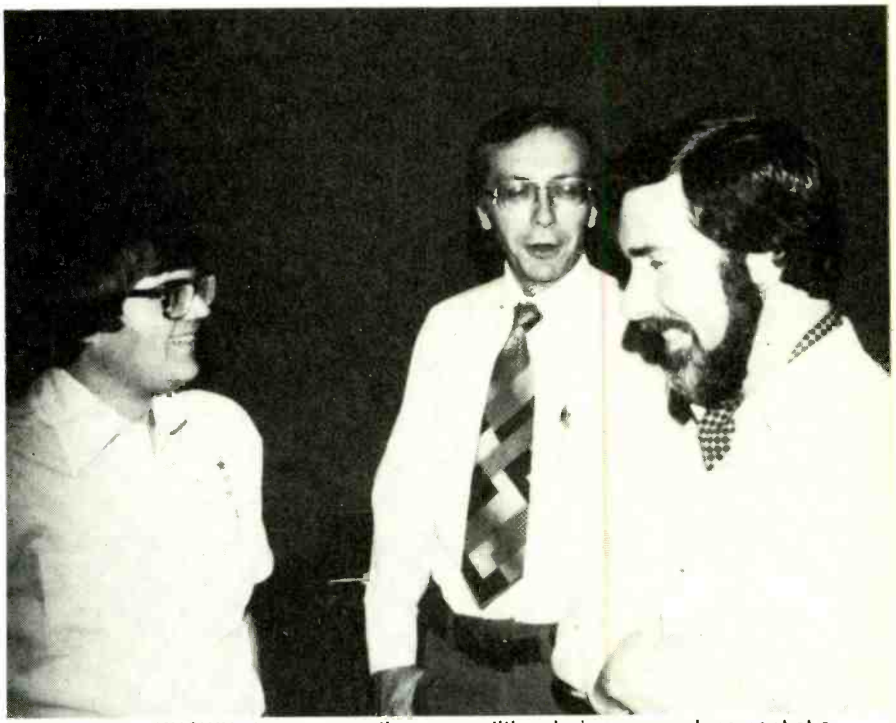
South Africa—*Radio RSA*, Johannesburg, at 0200 on 9,615 kHz.

Taiwan—*Voice of Free China* (relayed by US shortwave station, WYFR) at 0200 on 5.985 kHz.

USSR—*Radio Moscow* at 0130 on 9,700 kHz.

Vatican—*Vatican Radio* at 0050 GMT/UTC on 6,015 kHz.

There you have 16 stations—not quite from A to Z—with English broadcasts. A word of caution, however: While that data was correct at the time of writing, times and, especially, frequencies of shortwave stations change seasonally. If you don't find the station you're looking for, tune around a bit at the same time and the chances are that you will locate it on another frequency.



THREE WELL-KNOWN shortwave radio personalities during a casual moment at a recent convention of the Association of North American Radio Clubs. Conversing here are, from left, Jeff White, producer and host of the *Radio Earth International* program; Roger Stubbe of HCJB, Quito, Ecuador; and Ian McFarland, host of the popular SWL Digest program on *Radio Canada* International. ANARCON '84 will be held in July in Toronto.

More Changes

Last time, I mentioned a new shortwave program called *Radio Earth International*, which then was broadcasting a nightly one-hour program from the facilities of *Radio Clarin* in the Dominican Republic. But by the time you read that in my last column, things had changed.

Radio Earth International now airs its daily program, called *The World*, at 0400 GMT/UTC via shortwave station, WRNO, New Orleans, on 6,185KHz. *Radio Earth*'s address is Box 69, Miami, FL 33243.

Big Get-Together

Have you ever wanted to meet other people interested in this same interesting hobby of DX'ing distant stations? Spend a weekend talking radio, stations and programs you listen to, swapping experiences with different types of listening equipment?

Last summer, about 300 radio-listening hobbyists gathered in Washington, DC at the convention of the Association of North American Radio Clubs.

They had a great time!

If you missed that, how about attending ANARCON '84, which will be held during the weekend of July 20, 21, 22 at Toronto, Ontario, Canada.

The 1984 gathering of DX'ers will also feature programs by well-known shortwave personalities. The weekend event will be hosted by the Ontario DX Association, for ANARC.

Everyone is invited. For details, write ANARCON '84, c/o 3 Camrose Crescent, Scarborough, Ontario M1I-2B5, Canada. —*Don Jensen*

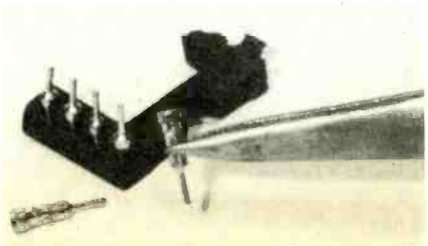
TESTBENCH TIPS

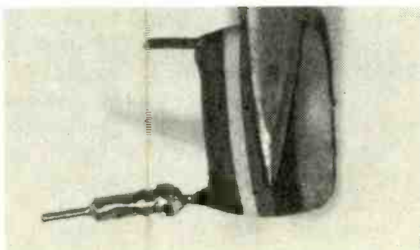
(Continued from page 17)

oxidized. It will work if you unbraid the shield into three or four pigtails about the diameter of #22 or #24 wire and then coat the pigtails very thoroughly with non-corrosive soldering paste (flux). Work the paste into the pigtail with you fingers. Then try the homebrew solder wick. It will work almost as good as the real thing—and the price is better.

Lead Stretcher

It happens all the time: you reach into the parts drawer, and the only component there was salvaged from a printed-circuit board, and the leads aren't even long enough so you can twist them to a longer length of wire. You can easily extend the leads with pin terminals salvaged from an integrated-circuit socket. (Always keep a few pieces of socket lying around just for this purpose.) Carefully cut the



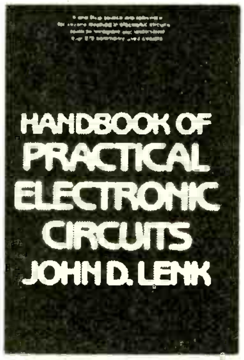


socket near a pin and then ease the pin free. Place a drop of solder in the pin's cup, and while still hot, slip the component's lead into the cup. Not only will the pins pass through a printed-circuit board, but the cups will keep the component's leads in position during soldering. **SP**

THE BOOKSHELF

(Continued from page 95)

cuits as a technician, designer, experimenter, or student, *Handbook of Practical Electronic Circuits* is a valuable one-stop source or reference. Using this handbook you will be able to recognize more than 270 circuits commonly used in



all phases of electronics. You will understand how they operate and how they fit into electronic equipment and systems.

The author describes the details of circuit design in practical terms; explains, simply and completely, the "why" and "how" of circuit performance; and includes many circuits using popular control rectifiers, such as SCRs, SCSs, triacs, diacs, SUSs, SBSs, LASCRs, LASCSs, and opto-couplers. He also offers detailed practical circuits for interfacing between digital electronic equipment and various control systems.

John D. Lenk, a consulting technical writer has best selling books covering a wide range of subjects, including solid-state troubleshooting, electrical wiring, and electronic circuit design.

Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. Hardcover, 334 pages, $21.95.

The Build-it Book of Electronic Projects by Rudolf F. Graf & George J. Whalen

So you like to build projects! How about some practical, easy-to-build electronic equipment for home and auto, security devices, games and gadgets, and more! Or, maybe, you are looking for easy-to-follow plans for an electronic football game or a "smart" sound-activated switch! All the information needed to build those and dozen more exciting and useful electronics devices are here in this project book--*The Build-It Book of Electronic Projects*! It's a huge collection of projects designed to save time and money, to help hobbyists and home-owners keep up with home and auto maintenance details, to protect their family and possessions, to build their electronics knowledge, and to provide them with hours of fascinating and challenging electronics practice!

And, there's lots more! Each project

includes easy-to-follow, step-by-step instructions supported by plenty of detailed drawings and schematic diagrams as well as a complete parts list. Every device can be made inexpensively from easily accessible components. And, best of all, each device has been thoroughly tested and proven so readers can be sure that once built, it will really *work*!

Rudolf Graf is an electronics engineer and a senior member of the IEEE. George J. Whalen is a design consultant, inventor, and professional writer who holds several patents in electronics and thermodynamics.

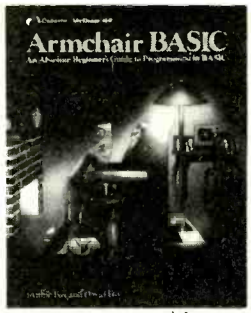
Tab Books Inc., Blue Ridge Summit, PA 17214. Paperback, 264 pages, $9.95.

Armchair BASIC Annie Fox and David Fox

Authors Annie and David Fox have written an introductry book on the most popular of all microprogramming languages--*Armchair BASIC*. This book is written especially for beginners who do not have access to microcomputers but wish to become familiar with programming concepts. As they explain, *Armchair BASIC* is written with humor and compassion for the computer neophyte, who, due to math phobia and other like maladies, has, until now, successfully resisted all conversion attempts made by computer enthusiasts. It is dedicated to the proposition that *anyone can learn programming* and is designed for the casually curious as well as the utterly baffled individual who is finally ready to join the "computer revolution."

Using a profusion of illustrations, metaphors, and examples, the authors present programming fundamentals which are applicable to any computer that speaks BASIC (Apple, TRS-80, IBM PC, PET, and others). After a brief description of the working parts of a microcomputer system the authors discuss essential concepts: variables, data input, if/then statements, controlled loops, random numbers, read/data statements, subroutines, and finally a chapter on the future of computers.

Annie and David Fox, both self-taught computer users, are founders of the Marin Computer Center, the first public access

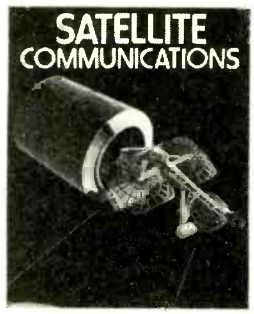


center open to anyone with an interest in using microcomputers for personal and business applications.

Osborne/McGraw-Hill, 630 Bancroft Way, Berkeley, CA 94710. Paperback, 264 pages, $11.95.

Satellite Communications by Stan Prentiss

In his new book, author Stan Prentiss takes a complete look at communications satellites presently in orbit and those under construction for future launching. He explains in simple language the geo-synchronous orbits followed by those sat-



VARIABLE PULSE GENERATOR

(Continued from page 89)

values, these must be considered if you want it to be somewhere in the timing range you will be needing. Capacitors C2 and C3 may not even be required. In some cases pin 5 may be left floating. However, a signal which is able to get into this pin will modulate the output waveform. The capacitor by-passing the DC supply is recommended, but again may not be needed. A quick check—connect an oscilloscope to the lead going to the battery/power supply and ground. If clean, you may eliminate C3.

Now it's time to start wiring up your version of the Variable Pulse Generator and perhaps make a permanent model for use on your test bench. Remember, don't be afriad to experiment with the circuit. It is doubtful you can hurt much with the worst being the integrated circuit chip. But even that is available for just pennies these days. Happy building! **SP** ellites including the ways that satellites are kept in their proper orbits, and data on the signals transmitted and received from those space units! The text presents in-depth information on fixed satellite and direct broadcast satellite service, transmitters and TVRO receivers, interference problems, scrambling devices used by some satellite companies, and the satellites used by cable television companies!

Here, for the taking, are all the answers to just about any question about communications satellites and state-of-the-art developments in the fascinating field of geosynchronous satellite technology. Written in logical, easy-to-follow format, this book covers all the various disciplines of satellite communications, including practical data on uplink and downlink transceivers, TVRO stations, and even an overview of what's in store for the future.

Stan Prentiss is one of the leading electronics writers in the U.S. He has written many books for Tab Books including *The Complete Book of Oscilloscopes.*

Tab Books Inc., Blue Ridge Summit, PA 17214. Paperback, 280 pages, $10.95.

LETTERS

(Continued from page 7)

or DC currents, but then I haven't measured current in the last few months. Check one out—you'll like it!

THANKS

Special Projects really came up with a winner when they published *Digital Capacitance Meter* in the Winter 1984 issue. I read the story several times, unable to believe that a project could be so simple and do so much. Since I have already developed a four-digit, LED display section for my workbench, I had half the work done at start! With a few changes in the range selection circuit to suit my fancy, the finished project was just unbeatable by other devices costing 100 times as much. (*Well, maybe not 100 times as much—Editor*) The basic timing circuit and clock generator remained unchanged. Now, what can you do in the way of presenting your reading public a project that will measure inductances, especially those in the milliHenry range?

JOHN D.
Phoenix, AZ

Thanks for the kind words! We like to hear that our projects are useful to our readers. More so, we like to hear that you improved on them, or adapted them for a special purpose or function. Your ingenious application for your workbench activities proves to us that ***Special Projects*** *is of considerable importance to electronics experimenters in North America. There is nothing in our files at the present time that we can offer as plans to make an inductance tester at any range. This editor still does it the old-fashion way—loading a coil with a known capacitor, placing the pair across a signal generator and tuning for resonance. The* Digital Capacitor Meter *will vary this approach somewhat making life a bit easier.* **SP**

ADVERTISING INDEX

SPECIAL PROJECTS magazine does not assume any responsibility for errors that may appear in the index below.